Summary of power utilized on the tributaries of the Missouri river.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Sundry streams	Missouri	Montana territory			24	715½	654
Do	do	Wyoming territory			2	25	38
Small streams	do	Dakota territory			4	51	127
Dakota	do	do			6	47½	228
Vermillion	do	do			5	35	133
Big Sioux and tributaries	do	Dakota territory (mainly)			10	159½	673
Floyd	do	Iowa			2	22	61
Little Sioux and tributaries	do	do			21	213½	907
Soldier	do	do			2	13	57
Boyer and tributaries	do	do			9	79½	242
Platte and tributaries	do	Nebraska and Colorado			84	1,069½	4,157
Little Nemaha	do	Nebraska			9	99	228
Small streams	do	Iowa			7	82	234
Do	do	Nebraska			21	209½	622
Nemaha and tributaries	do	Nebraska (mainly)			14	150½	404
Nishnabatona and tributaries	do	Iowa (mainly)			23	219	701
Big Tarkio and tributaries	do	Missouri and Iowa			5	46	133
Nodaway and tributaries	do	do			18	159	449
Platte and tributaries	do	do			23	202	869
Kansas and tributaries	do	Kansas and Nebraska			145	1,345	6,561
Grand and tributaries	do	Missouri and Iowa			37	200	1,063
Chariton and tributaries	do	do			6	50	215
Osage and tributaries	do	Missouri and Kansas			58	730½	1,347
Gasconade and tributaries	do	Missouri			23	253	386
Small streams	do	Kansas			1	15	50
Do	do	Missouri			16	218½	350
Total for the Missouri river basin					581	6,584	21,012

V.—THE EASTERN IOWA SLOPE.

The section thus designated lies east of the water-shed line, which, passing southerly through Iowa, divides the basin of the Mississippi from that of the Missouri. The principal streams are as follows:

	Square miles.
Maquoketa river, drainage area	1,921
Wapsipinicon river, drainage area	2,568
Iowa river, drainage area	12,519
Skunk river, drainage area	4,409
Des Moines river, drainage area	14,578
Total	35,995

I omit from this list the Turkey and Upper Iowa rivers, which properly belong to eastern Iowa, but were not within the district assigned to me for examination.

The Upper Des Moines and Cedar rivers drain limited areas in southern Minnesota, and the lower valley of the Des Moines includes a narrow strip in northeastern Missouri; otherwise the basins of the streams to be considered are within the state of Iowa. The surface is usually an undulating prairie, but in some localities, as to the west of Fort Dodge, closely approaches a level; there is only a small percentage of timber, and that exists mainly as fringes along the water-courses. Scattered over the upper basins of the rivers are many natural ponds of small size, and occasionally there is a lake of several square miles area. As shown by the courses of the streams, the country has a general declivity to the southeast; from Spirit lake, in the northwest, to the mouth of the Des Moines, the average amount of this declivity is 4½ feet per mile. The mean elevation of the surface may be taken as 900 to 1,000 feet above sea-level, the altitude of various points being shown in the accompanying table.

Altitude of points on the eastern Iowa slope.

Locality.	Elevation above sea.	Authority and remarks.
"Great" water-shed:	*Feet.*	
Spirit lake, high ground near	1,722	*Geology of Iowa.*
Summit between Raccoon and Little Sioux rivers	1,486	*Geology of Iowa.* Illinois Central railroad levels.
Tip-top station, Chicago and Northwestern railway	1,441	*Geology of Iowa.* Chicago and Northwestern railway levels.
Summit of Great water-shed	1,451	*Geology of Iowa.* From levels Chicago, Rock Island and Pacific railway.
Intermediate:		
Cedar Rapids	721	*Geology of Iowa.* Water surface at Chicago and Northwestern railway crossing.
Marshalltown	910	*Geology of Iowa.* Rails Chicago and Northwestern railway.
Des Moines	786	Water surface by old survey.
Fort Dodge	1,537	Water surface at Illinois Central railroad crossing.
Mississippi river:		
Mouth of Maquoketa river	572	Levels of Major Farquhar, connecting with Lake Michigan.
Mouth of Wapsipinicon river	559	Do.
Mouth of Iowa river	522	Do.
Mouth of Skunk river	505	Do.
Mouth of Des Moines river	476	Do.

NOTE.—Elevations from the *Geology of Iowa* have been corrected to make planes of reference agree in elevation with more recent determinations.

The soil is of Drift formation and is very productive, yielding largely in corn, wheat, grass, and oats. According to the *Iowa Agricultural Report* for 1879, about 40 per cent. of the entire surface of the state was estimated to be still uncultivated. This percentage would be exceeded, however, in the northern and northwestern portions of the state, where the soil is somewhat less fertile than elsewhere, and settlement less dense. The Drift, which constitutes the principal surface deposit throughout eastern Iowa, is generally very thick. At many points it attains a depth of 100 feet, and is even 150 to 200 feet thick along the Great water-shed which separates the basins of the Mississippi and Missouri rivers. But along the course of the Shell Rock river, in northern Iowa, the deposit is said to be comparatively thin. The material of the Drift in Iowa is usually composed of the finer constituents, and therefore offers no serious hindrance to agriculture; it has an important influence upon the streams, inasmuch as it is well supplied with springs, which contribute to the steadiness of their flow. There is, in the latter respect, a marked contrast to the western Iowa slope, where the Loess is entirely lacking in springs.

Beneath the surface deposit of Drift are found the various rock formations, all stratified, and composed mainly of limestones. They are either horizontal or inclined at a very slight angle toward the south. They are frequently exposed in the beds of the streams, but do not create either abrupt falls or rapids of more than moderate pitch. Bituminous coal is found throughout the lower basin of the Des Moines, and at various points east and north valuable quarries of limestone suitable for building have been opened.

In the section under consideration the prevailing winds of the year are westerly, coming from the northwest in winter, and from the southwest, the rainy quarter, in summer. In the latter season violent wind-storms, and even tornadoes, are not uncommon. The summer rainfall is also sometimes excessively great. Thus, according to the Signal Service observations at Des Moines, the rainfall in June, 1881, was 15.79 inches, or considerably more than the usual amount for the entire summer. The average annual amount of snow in the southeastern part of the state is 33 inches.

Rainfall and temperature, eastern Iowa slope.

[From Smithsonian records.]

Locality.	Latitude.	Longitude.	Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
RAINFALL.	° ′	° ′		*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Fort Dodge	42 31	94 12	4	7.98	12.63	6.15	3.14	29.90
Des Moines	41 36	93 38	4	5.13	13.16	7.03	3.16	29.38
Independence	42 29	91 57	8	8.58	12.69	6.98	4.05	32.30
Iowa City	41 37	91 30	15	10.07	14.41	11.16	5.54	41.78
Dubuque	42 30	90 40	23	8.12	11.73	8.74	5.07	33.66
Keokuk	40 25	91 21	4	9.18	16.49	8.97	8.60	43.24
TEMPERATURE.				°	°	°	°	°
Fort Dodge	42 31	94 12	4	42.57	73.04	49.16	18.97	45.94
Des Moines	41 36	93 38	4	49.99	71.80	48.59	25.39	48.04
Independence	42 29	91 57	7	43.98	70.48	47.51	19.18	45.20
Iowa City	41 37	91 30	12	46.23	71.25	49.62	22.69	47.45
Dubuque	42 30	90 40	19	47.33	71.71	49.16	22.55	47.60
Keokuk	40 25	91 21	2	50.09	74.77	54.05	29.37	52.07

The streams which are to be described already furnish power to a large aggregate number of flouring- and grist mills, and at a few points on the Cedar, Iowa, and Des Moines manufacturing centers of some prominence have been developed. A large amount of fall is still unimproved, however, but will doubtless be taken up with the growth of the country in population and wealth. The Des Moines river in particular, from its size and the favorable character of its bed, offers facilities for water-power improvements on an important scale. None of these rivers are navigable, but the Mississippi river, on the east, and a network of well-equipped railway lines, furnish easy means of communication with all important markets and sources of supply. Corn, wheat, and wool are close at hand; iron, lead, and zinc are easily obtained in Missouri, to the south, and lumber is to be had from the north.

The rivers of eastern Iowa are characterized by gentle currents and a usually well-sustained flow. The beds are muddy in some sections, but are more commonly of gravel, and display numerous exposures of rock. The banks are of moderate height, and are occasionally submerged during freshets. High water occurs during spring and early summer, and is followed by a falling stage, with a minimum in late summer, fall, or, during a severe winter, in the latter season.

In the absence of all records whatever of gaugings upon any of these streams, I have been compelled to rely upon my own estimates of their volume in order to form some idea of the amount of power they are capable of furnishing. In making these estimates I have been largely guided by a comparison with three other streams—the upper Mississippi, the Minnesota, and the Illinois, the volumes of which, as determined by government engineers, are given below. So far as possible, I have also taken into account the individual features of each river.

Low-water volumes of the Mississippi, Minnesota, and Illinois rivers.

[Drainage areas of the Mississippi and Illinois are as measured by Mr. James L. Greenleaf.]

River and locality.	Rainfall on tributary area (approximate.)					Drainage area.	Volume, cubic feet per second.	Cubic feet per second per square mile.	Authority and remarks.
	Spring.	Summer.	Autumn.	Winter.	Year.				
MISSISSIPPI.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*			
Frenchman's Bar	6	12	6	3	27	35,824	5,000	0.140	The upper basin, above latitude 44° to 45°, is thickly wooded and contains many lakes and swamps. The volumes here given are those adopted for low-water discharge in the government survey. With regard to the low-water line determined by that survey it is stated that "extreme low water occurring during the winter or from ice gorges has not been considered in determining the low-water line as not influencing navigation". (See report by Captain A. Mackenzie, corps of engineers, pages 1517 and 1519 *Report Chief of Engineers for* 1880.)
Wabasha	6½	12	7	3	28½	*55,870	10,000	0.179	
Winona	6½	12	7	3	28½	†59,250	11,000	0.186	
Johnsonsport							14,000		
Below Wisconsin river	7	12	7	3½	29½	78,565	17,000	0.216	
Lyons	7	12	7½	3½	30	‡84,857	18,500	0.218	
Princeton	7	12	7½	3½	30	‡87,558	19,000	0.217	
Rock Island	7	12	7½	3½	30	87,842	19,000	0.216	
Burlington	7½	12	7½	4	31	113,495	22,000	0.194	
Canton	7½	12	8	4	31½	133,995	26,000	0.194	
Hannibal	7½	12	8	4	31½	137,460	30,000	0.218	
MINNESOTA.									
Foot Big Stone lake	6½	12	5	3	26½	920	11	0.012	Volumes as given in report by General G. K. Warren, corps of engineers. (See appendix J, *Report Chief of Engineers*, 1875.) These volumes were given as the lowest that had been observed, but the river may have been even lower at other times. The basin of the Minnesota contains a considerable number of small lakes and ponds, and a few with areas of 5 to 10 square miles or even more. The country is thickly timbered below Judson and Mankato, but is an open prairie above.
Above Pomme de Terre creek	6½	12	5	3	26½	2,620	42	0.016	
Above Redwood river	6½	11	5	3	25½	8,540	217	0.025	
Fort Ridgeley	6½	11	5	3	25½	9,850	253	0.026	
Above Big Cottonwood river	6½	11	5	3	25½	10,100	307	0.030	
Judson	6½	11	5	3	25½	11,040	307	0.033	
Belle Plaine	6½	11	5½	3	26	10,380	1,575	0.096	
Above Little Rapids §	6½	11	5½	3	26	10,660	1,024	0.115	
Mouth of river	6½	11	5½	3	26	17,230	‖1,155	0.067	
ILLINOIS. ¶									
At mouth	11½	11	9	8	39½	29,013	1,600	0.055	Extreme low water as given by Major G. J. Lydecker, corps of engineers. Basin is a rather flat prairie, swampy toward the headwaters.
At mouth	11½	11	9	8	39½	29,013	1,750	0.060	Ordinary low water as given by Major Lydecker.

* Mouth Chippewa river.
† Mouth Trempealeau river.
‡ Approximate.
§ Thirty miles from the mouth.
‖ Observed November 25, 1867.
¶ Concerning this stream Major Lydecker says: "The Illinois river is a very flat stream, and is fed mainly by the rainfall on a prairie country; the bottom-lands adjoining its bed are low, and cut up by numerous lagoons or lakes that hold the water back. Excepting in times of freshet, or after a long period of heavy rains when the bottoms are full, the water of rainfalls is slow to reach the stream, and correspondingly sluggish in its movement to the mouth. Again, the water that finds its way into the river above the dams at Copperas creek and Henry (by which slack-water is created on its upper portion) is held back in the pools created by these dams * * * ". The average slope toward the mouth is about 0 15 foot per mile.

Assumed rates of discharge for the eastern Iowa rivers.

Stream and locality.	Rainfall (approximate).					Drainage area.	Assumed discharge in cubic feet per second per square mile.			Remarks.
	Spring.	Summer.	Autumn.	Winter.	Year.		Low-water, ordinarily dry year.	Low-water, average year.	Available ten months in average year.	
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Sq. miles.*				
Maquoketa, at mouth	10	12	8½	4½	35	1,921	0.004	0.114	0.172	Basin is rolling prairie, covered with Drift. Frequent rock exposures.
Wapsipinicon, at mouth	8½	12	9½	6	36	2,568	0.003	0.117	0.175	Drains rolling prairie covered with Drift. Frequent rock exposures.
Cedar, at mouth	9½	13½	8½	4½	36	7,715	0.006	0.110	0.175	Largely fed by springs. Drift is shallow in upper basin, and rock frequently exposed.
Iowa, above Cedar	10	13½	11	6	40½	4,407	0.002	0.107	0.175	Rolling prairie with Drift. Frequent rock exposures.
Skunk, at mouth	9	14	9½	4	36½	4,469	0.001	0.082	0.126	Rolling prairie covered with Drift. Not much rock exposed, except in lower course. Stream said to be unreliable.
Des Moines, at mouth	8½	13½	9	4	35	14,578	0.078	0.000	0.135	Upper basin slightly undulating; Drift soil of considerable depth, much less cultivated as yet than in the eastern part of the state; very little timber, but region well supplied with springs.

VI.—RIVERS OF THE EASTERN IOWA SLOPE.

THE MAQUOKETA RIVER.

The Maquoketa is the first and most easterly of the streams which I shall consider. It rises in Fayette county, 30 to 35 miles west of the Mississippi, runs southeasterly, and empties into the latter river in Jackson county, approximately midway between Clinton and Dubuque. It is 95 miles long by general course, and drains 1,921 square miles. This section is underlaid by Niagara limestone, valuable quarries of which have been opened at Farley, on the Illinois Central railroad. The rough weathering of this stone has given the valley of the river quite a wild and romantic appearance in places. The valley is not deep, however, being seldom depressed as much as 200 feet below the general level of the surrounding uplands, to which there is usually a gentle rise.

Elevations on the Maquoketa river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft per mile.*
Manchester†	905	333	87	3.83
Mouth of river‡	572			

*Map measurement.
† Low water at Illinois Central railroad crossing.
‡ Low water in Mississippi river, by levels of Major Farquhar, connecting with lake Superior.

The Maquoketa is said to be a good stream for milling, and is so employed to a moderate extent by flouring and grist-mills, a summary of which is given in a subsequent table. The railroad facilities are good, and below Manchester the stream is at no point distant more than 7 miles from some line, and is crossed at several localities. The principal towns are Maquoketa, population about 2,500; Monticello, 1,900, and Manchester, 2,300.

Estimated volume and horse-power of the Maquoketa river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
At Delhi	386	30	34	40	45	60	68
At Monticello	642	50	57	70	80	110	125
At Maquoketa, above North Fork	995	90	102	120	136	170	193
At mouth	1,921	180	204	220	250	330	375
North Fork, at mouth	580	40	45	70	80	100	114

THE WAPSIPINICON RIVER.

This river lies next south of the Maquoketa, and is remarkable for its long and narrow drainage basin. The latter contains an area of 2,568 square miles, and is 185 miles long; yet its width is only 10 to 20 miles, till, within a short distance of the mouth, it widens out to 25 miles. Draining so narrow a strip, it receives no important tributaries, and is probably subject to less rapid rise and fall than it would be if the area were more extended, since, during a generally-prevailing storm, its accessions are not concentrated, but quite uniformly distributed over the whole course. Still the Wapsipinicon is liable to important oscillations, and during the heavy rains of June overflows its banks, in the lower course at least, though not commonly to a dangerous extent.

The source of this stream is in southeastern Minnesota, only a few miles above the Iowa boundary; entering Iowa, it runs southeasterly and joins the Mississippi 10 miles southwest of Clinton. The upper basin is underlaid by the Devonian formation, but below Buchanan county the course of the river is over the Niagara limestone. The valley is, in general features, like the valleys of the Cedar and Maquoketa rivers, which adjoin it on either side. In the vicinity of Anamosa it is quite narrow and picturesque; the bed and banks are rocky, the latter rising to a good height and frequently running abruptly up into bluffs.

The Wapsipinicon is a good milling stream; its firm banks, and the frequent exposures of rock in its bed, are favorable to dams, and the flow is quite steady and well sustained. This part of Iowa is well supplied with railroads, but above Anamosa they usually cross the basin of the river at a large angle, and do not, therefore, give as good facilities as are enjoyed by the lower river, where the immediate valley is followed more closely. The principal towns are New Hampton, population about 1,100, near the upper waters; Independence, 3,700, on the middle course; and Anamosa, 2,100, some 40 miles, by general course, farther down.

The slope of the stream is approximately as follows:

Slope of the Wapsipinicon river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Independence†	887	198	95	2.08
Near Wheatland‡	689			
Mouth of river§	559	130	40	3.25

* Map measurement.

† Low water at Illinois Central railroad crossing.

‡ Water surface at Chicago and Northwestern railway crossing.

§ Low water in Mississippi river, by levels of Major Farquhar, connecting with lake Superior.

The use of this river for power is confined almost entirely to flouring- and grist-mills, of which a considerable number are scattered along its course. The highest privilege in use is said to be employed by a little saw-mill near the Minnesota line. Between that point and Independence there are flouring-mills at Martinsburg, Tripoli, Chatham, and possibly at one or two other places.

At Independence the river is 150 to 200 feet wide, with banks 6 to 10 feet high. The Independence flouring-mill is one of the largest on the river; it has 9 feet head, and uses 100 horse-power. The dam is leaky, yet only in very dry seasons is any trouble experienced from low water. The owner of the privilege thinks that with a tight dam it is good for 200 horse-power eight months in the year, and for 100 horse-power practically all the time. I estimate the power as below:

Estimate of power at Independence.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 9 feet head.
	Sq. miles.		
Low water, ordinarily dry year	1,056	90	92
Low water, average year		110	112
Available 10 months in average year		160	164

Below Independence there are reported to be 8 flouring-mills on the Wapsipinicon, most of which carry three runs of stone each. The dams are of varied construction, brush, framed, or stone, according to the local character of the river bed. They have stood well in most cases, the chief trouble being from ice; freshets, and, in two or three instances, undermining, have also wrought injury.

Near Anamosa there are valuable quarries of magnesian limestone. The river is about 150 feet wide in that section, and has a good current. Doane's flouring-mill at Anamosa has 7 feet head, carries three runs of stone, and is able to run at full capacity throughout the year. The proprietor thinks the privilege would carry six runs of stone in an ordinary low stage of water. Very little hindrance, lasting not more than a few days, is experienced from backwater. The dam is an old structure, part crib-work and part brush, the whole ballasted with stone. It is about 200 feet long, 7 feet high, and rests upon a rock ledge; one end abuts upon a rocky bank and the other upon a masonry abutment.

Estimated volume and horse-power of the Wapsipinicon river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Tripoli	371	20	23	40	45	50	57
Independence	1,056	90	102	110	125	160	182
Anamosa	1,560	140	159	180	204	260	295
Toronto	1,861	170	193	210	239	310	352
Mouth of river	2,508	240	273	300	341	450	511

THE IOWA RIVER.

The Iowa and its tributary, the Cedar, are by far the most important streams in Iowa so far as regards the extent of their employment for power. The former drains 4,467 square miles above its junction with the Cedar, while the basin of the latter measures, down to the same point, 7,715 square miles. The Cedar is, therefore, much the larger of the two; nevertheless, below their junction the main river takes on the name of the smaller stream, and is called the Iowa. (*a*)

This river rises in Hancock county, in northern Iowa, and flowing southeasterly enters the Mississippi in Louisa county. Its course is quite crooked, and disregarding the minor curves measures about 215 miles in length from source to mouth. Its own basin varies from 12 to 35 miles in width, being rather narrow above Marshalltown, while below that point it broadens out. The country is well cultivated, and has a comparatively thick settlement. The more important towns on the river, with their populations in round numbers, are as follows, beginning at the mouth: Wapello, 900; Columbus Junction, 800; Iowa City, 7,100; Marengo, 1,700; Tama, 1,300; Toledo (3 miles from the river), 1,000; Marshalltown (near river), 6,200; Eldora, 1,600, and Iowa Falls, 1,000. The river is crossed at frequent intervals by railways, and, except at the extreme headwaters, is nowhere distant more than a few miles from some established line.

As stated by Dr. White, the Iowa rises "in the midst of a broad, flat or slightly undulating Drift region. The first rock exposed in its valley is the sub-Carboniferous limestone, which occurs in the form of rocky banks to the stream in the southwestern corner of Franklin county. The river then enters Hardin county, and cuts across the northeastern corner of the Iowa coal-field in a southeasterly direction, and enters the region of the sub-Carboniferous

a Above its junction with the Mississippi, the total drainage area of the Iowa river and its tributaries is 12,519 square miles.

limestone again, which it crosses, continuing in the same direction, and enters the region of the Devonian strata near the southwestern corner of Benton county. It continues in the region occupied by the Devonian rocks all the way to its confluence with the Cedar."

The bottom-land bordering the stream varies greatly in width. At Iowa Falls, on the upper river, the valley sides close in, and there is scarcely any bottom. The bed and banks are there rocky, though muddy in the neighboring sections above and below. From Iowa Falls to Eldora, 14 miles by straight course down the river, the banks are generally low. The river is about 100 feet wide at Marshalltown, and 300 feet wide at Iowa City. From Tama to the latter point the valley is generally narrow, with bluffy sides, but widens out at Coralville, just above Iowa City. Over the section just mentioned the bed is usually rocky. The Drift which covers this region is well supplied with springs, and these give the river quite a steady flow and sustain it during droughts. It nevertheless happens once in two or three years that, during an uncommonly dry season or severe winter, the supply of water is greatly curtailed and the river runs low. The bottom-land is occasionally submerged during the high water of spring or early summer; a freshet rise of 10 feet has been observed at Iowa Falls, and a rise of 14 feet at Marshalltown. At the latter point the Iowa formerly overflowed the bottoms every year, but was reported not to have done so for three or four years previous to 1881. For the short period of extreme high water the mills on the river are hindered by backwater.

Slope of the Iowa river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Near Iowa Falls*	1,007	102	65	2.40
Near Montour†	845	238	90	2.64
Iowa City‡	607	85	60	1.42
Mouth of river§	522			

*Low water at Illinois Central railroad crossing.
†Water surface at Chicago and Northwestern railway crossing.
‡From *Geology of Iowa.* Bed at Chicago, Rock Island and Pacific railway crossing.
§Low water in Mississippi river, by levels of Major Farquhar, connecting with lake Superior.

Far the largest employment of power on this river is by flouring-mills; still, at such points as Tama, Amana, and Coralville are to be found numerous concerns, of moderate size, devoted to various branches of general manufacturing.

In Louisa county, on the lower river, there is a single flouring-mill, using 9 feet head and 85 horse-power. Above this point there is no use of power until Iowa City is reached, where Dietz & Hemmer have a flouring-mill, with a log dam and about 4 feet fall.

The next improved privilege is at Coralville, a mile or two above Iowa City, and is owned by Mr. M. T. Close. The dam was built in 1868, is 300 feet long, 9 feet high, and has rock abutments. The bed is rock half-way across the stream and quicksand the remainder of the distance. The dam is a framed structure, with four sets of braces, and is ballasted with stone; it is provided with an apron of crib-work, planked over. A head of 9 to 11 feet is obtained, and the following mills are supplied with power: (*a*) One paper-mill, manufacturing wrapping-paper and straw-board, and using say 250 horse-power; one flouring-mill, with four runs of stone and 50 horse-power; one oatmeal-factory, with 60 horse-power, and a capacity of 2,500 bushels of oats per day.

Once in two or three years the river runs very low, and the mills are then liable to be short of water for perhaps two months; but ordinarily the supply is abundant, and more power could be furnished than is now used. Trouble is experienced with backwater for two to four weeks in the year.

Estimate of power at Coralville.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 9 feet head.
	Sq. miles.			
Low water, ordinarily dry year	3,188	290	32.9	296
Low water, average year		350	39.8	358
Available ten months in average year.		560	63.6	572

a The horse-powers given are the estimated amounts actually employed; the rated capacities of the wheels are considerably greater, and are, in the aggregate, 693 horse-power at this privilege. The paper-mill also employs 200 horse-power of steam as supplementary.

The next power employed is at Homestead, on the Chicago, Rock Island and Pacific railway, 18 miles northwesterly from Iowa City, and is owned by the Amana Society. Water is brought 7 miles, through a canal 65 feet wide, and supplies mills located at distances of 5 and 7 miles, respectively, from the head, with power as follows:

	Horse-power.
One starch-factory, 8 feet fall	40
One woolen-mill, 8 feet fall	40
One saw-mill, 8 feet fall	40
One woolen-mill, 12 feet fall	65
One grist-mill, 12 feet fall	110
One saw-mill, 10 feet fall	40
Total (*a*)	335

Water is diverted into the canal by a dam at the head, built of brush and stone. It is 220 feet long, 4½ feet high, and was constructed in 1868. The privilege is considered to be good for 300 effective horse-power, even in cold winters when the ice is very thick. By methods previously explained, I estimate the power as below:

Estimated power of Iowa river at Homestead.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 12 feet head.
	Sq. miles.			
Low water, ordinarily dry year	2,900	270	30.7	368
Low water, average year		320	36.4	437
Available ten months in average year		510	57.0	695

At Marengo there is a brush dam 5 feet high, from which water is carried, through a canal three-quarters of a mile, to a flouring-mill of three or four runs. There is no other improved site below Tama. At that place several establishments are supplied with power, water being brought 3¾ miles through a canal 30 feet wide and 3 feet deep. At the head of the canal is a dam, which was built in 1880 at a cost of $2,000 to $3,000. It is 300 feet long, 3 to 4 feet high, and rests upon a bed of quicksand, which by actual sounding has been found to be 50 feet deep. For a foundation, rows of piling were driven and filled in with brush. On this substructure rests the dam, which is a framed structure filled in with stone. The apron is built of logs, resting upon the same foundation as the dam, and having a slight upward slope away from the latter. The canal, or race, which conveys water to the mills, is provided, at a distance of a quarter of a mile from the dam, with a heavy timber guard-lock. It also has waste-gates where it crosses Deer creek. It enlarges at one point to a reservoir of 20 acres, and ends in another of 60 acres having a maximum depth of 14 feet. A head of about 22 feet is available at the mills, though at the time of my visit only 14 feet was being used. There are six establishments, none of more than moderate size, and devoted, respectively, to the manufacture of flour, paper, sash and blinds, agricultural implements, tubs, and wind-mills. About 128 horse-power is in use altogether, and in the dryest seasons there is a large surplus of power. It is said that the privilege has been estimated to have a capacity of 600 horse-power in the lowest stage of water. I could learn of no regular charge for power; the flouring-mill pays $1,200 per annum for 40 horse-power, with the privilege of using it 24 hours in the day, the water-wheel being furnished by the lessor.

The enterprise was started about the year 1875, and has had an unfortunate history. Owing to the scour of water below the dam the old structure fell in with almost yearly regularity, and then had to be repaired, either in whole or in part. This was not only a source of expense, but it tended to frighten manufacturers from going there to locate. The race banks were not given a sufficiently flat slope to prevent them from washing, and the wooden flumes at the end of the race are said not to have been properly constructed. The development of the power is reported to have cost in all over $100,000. The original company failed, and the privilege came into the hands of Mr. Purley Starr, of Brattleboro', Vermont, who still held it at the time of my visit, but, as I was informed, would like to sell for $35,000, the amount of his claim. A citizen of Tama has offered to build a dam, and to guarantee, with proper security, that it shall stand. The present dam, which I have already described, is considered safe, however. There is a considerable amount of surplus power to let, but no efforts are made to induce the establishment of new concerns. The privilege is very conveniently situated, the mills being but a little way from the Chicago and Northwestern railroad. It is stated that they have no trouble from backwater, and on that account are able to run when most other mills on the stream are stopped.

a Amount actually used estimated at 270 horse-power.

Estimated power of Iowa river at Tama.

Stage of river.	Drainage area.	Volume in cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 10 feet head.	Theoretical horse-power, 22 feet head.
	Sq. miles.				
Low water, ordinarily dry year	1,963	170	19.3	193	425
Low water, average year		200	22.7	227	499
Available ten months in average year		320	36.4	364	801

There are two other flouring-mills on the river in Tama county besides the one mentioned at Tama City. Proceeding up stream and entering Marshall county, we find mills at Le Grand, Quarry, and Marshalltown. At the latter point the valley is perhaps a mile wide, and the river itself measures about 100 feet across. Power is used at Marshalltown by the Woodbury mills (flouring). The dam was built in 1877, and cost about $1,300. It is 144 feet long, 6 feet high, and is a framed structure, resting upon a rock ledge and provided with an apron of crib-work ballasted with stone. The water is set back up the river a distance of 2½ to 3 miles. The mill carries five runs of stone, and uses 75 horse-power, under a head of about 6 feet. No trouble is experienced from low water, although there is not much surplus in that stage. Backwater causes hindrance for from two to six weeks in the year, and the difficulty is aggravated by the formation of gorges when the ice breaks up in the spring.

Advancing up the river from Marshalltown the remaining mills are located, in order, as nearly as I can ascertain, as follows: One at Union, one at Xenia, one at Eldora of three runs, one at Steamboat Rock of three runs, one at Eagle City, two at Iowa Falls, two at Alden Rapids, one at Alden, one at Belmond, and one on the upper waters in Hancock county. All these are flouring-mills, except the lower one at Iowa Falls, which is a small woolen-mill.

The upper privilege at Iowa Falls is owned by Messrs. Woods & Wright, and employed to furnish power to a flouring-mill with three runs of stone. The present dam was built about the year 1868, and is 130 feet long, with a height of 14 feet above the river bed. In its construction heavy timbers, say 30 feet long, were laid on the rock bottom in the direction of the stream, and at intervals of 10 feet. Each was pinned to the rock at three points by 1¼-inch iron pins. The dam was then carried up as a crib-work, securely fastened together with iron pins and carefully packed with stone. By building up the face faster than the back the requisite slope was given to the top of the dam, which measures 25 feet from the crest to the end of the back slope, and is heavily planked. At each end is a stone abutment, protected below the dam by piling. The structure has answered its purpose finely. Before it was built three framed dams had been carried out by ice; in one case the timber braces projected too far in front of the dam, and, though 12 inches square, were snapped in two by heavy cakes of ice falling over the crest. The mill-pond sets back one mile above the dam. There is a head of 10½ feet on the wheels, which are of 35 horse-power (total). Occasionally, in a severe winter, the mill has been short of water, but this is said to have happened only twice in twenty years, and on the average there is 6 inches of water running to waste over the dam. Mr. Wright thinks the privilege would carry considerable additional machinery three-quarters of the year.

Of the minor tributaries of the Iowa, English river is the most important. It heads in Poweshiek county, whence it flows easterly to the main river, with a length, by general course, of about 65 miles. Its drainage area is 657 square miles. It decreases quite rapidly in size above the mouth, but is described as a good stream for powers of moderate amount. There are three flouring-mills on its course in Washington county, and three in Iowa county. Bear creek, which enters the Iowa from the west at Marengo, is a much smaller stream than English river, but furnishes power to two small flouring- and grist-mills.

I am unable to give the locations of available sites for power, still unimproved, on the Iowa river, though numerous ones doubtless exist. Of the entire fall of 485 feet between Iowa Falls and the mouth, only about 160 feet, or 33 per cent., is at present improved. The following table is a summary of the estimated power of the river at different points in its course:

Estimated volume and horse-power of the Iowa river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Iowa Falls	660	50	57	60	68	110	125
Marshalltown	1,440	110	125	150	170	240	273
Tama	1,930	170	193	200	227	320	364
Marengo	2,823	260	295	310	352	500	568
Homestead	2,900	270	307	320	364	510	579
Iowa City	3,290	300	341	360	409	580	659
Above English river	4,294	390	443	470	534	750	852
Above Cedar river	4,467	410	466	480	545	780	886
English river	657	60	68	80	91	120	136

THE CEDAR RIVER. (a)

This important stream has its sources in southeastern Minnesota, in Dodge and Freeborn counties, 20 to 25 miles above the northern boundary of Iowa; entering the latter state it runs southeasterly till, in Louisa county, it joins the Iowa river, of which it is the principal branch. It has a length, by general course, of about 220 miles, and a drainage area of 7,715 square miles. The surface of the country is a gently undulating prairie, apparently level in some sections, with a moderate amount of timber in the form of groves or fringes along the streams. Peat beds and marshes are found in the northern counties, and there are a few lakes, of which the more important are Clear lake, in Cerro Gordo county, Iowa, having an area of 8 or 10 square miles; and Geneva, Rice, Freeborn, and Albert Lea lakes, in Freeborn county, Minnesota, containing 2 to 5 square miles each. The upper basin of the river has a width of about 50 miles; the lower basin is much narrower, however, and below Cedar Rapids, in southeastern Linn county, measures only 8 or 9 miles across. The principal tributary streams, in order from the mouth, are Wolf creek, Black Hawk creek, Beaver creek, Shell Rock river, and Little Cedar river; of these the Shell Rock, with a drainage area of 2,631 square miles, is much the largest.

The section drained by the Cedar has a Drift soil, largely a sandy or gravelly loam. It is very fertile, and, as a rule, yields well in corn, wheat, and other grains. Stock is also largely raised. Wheat has been the main production in the upper basin, but it is said that frequent failures of the crop there of late years have led the farmers to turn their attention to flax. The country is well settled, the entire population of the Cedar River basin having been estimated at 374,587 in 1880, an increase of over 83,000 since 1870. The larger towns on the course of the river in Iowa, from the mouth up stream, are Cedar Rapids, population about 10,000; Vinton, 2,900; La Porte, 1,000; Waterloo, 5,600; Cedar Falls, 3,000; Waverly, 2,300; Nashua, 1,100; Charles City, 2,400; and Osage, 2,000. This region is intersected by numerous and well-appointed railroads. The Cedar river is nowhere distant more than 6 miles from some line, and much of the way, especially in the upper half of its course, is closely skirted.

The entire course of the river is over the firm, compact limestone of the Devonian formation. This stream and its tributuries are stated by Dr. White to have more numerous and extensive exposures of rock along their valley than either the Iowa, Skunk, or Des Moines; the exposures usually appear as rocky banks to the streams, sometimes as cliffs rising 20 to 30 feet above them. The fall of the stream I am now describing is moderate, but it derives much value for power from the favorable character of its bed and banks, and its considerable and well-sustained volume. The rock exposures appear to be most numerous in the upper half of its course, and are to be accounted for in part by the hardness of the formation to which they belong; and also by the thinness of the overlying Drift in the upper basin, rendering it an easy task for the streams to cut their way down to rock. Although the river-bed contains so much rock, it is explained by Dr. White that, in consequence of its course coinciding closely with the general trend of the Devonian formation, it meets with little obstruction from them, and no falls or rapids of importance are formed.

The comparatively steady flow of the river is doubtless due to the general character of its basin. The Drift of Iowa is naturally well supplied with springs, and thus we find many spring-brooks feeding the upper Cedar; the country is well settled, and the ground has been, to a considerable extent, broken up for agriculture and rendered receptive of water; and, again, the slight depth of the Drift allows the water soon to find its way to the underlying rock, whence much is shed into the water-courses without sinking to lower depths. Still, it must not be supposed that the Cedar is free from considerable oscillations, for it is certainly true that during an unusually dry summer or severe winter its volume becomes much reduced. High water commonly occurs in June, but at Charles City, in the upper waters, the rise does not exceed 4 feet.

The valleys of this river and its tributaries are rather narrow in the upper basin, with gently sloping sides; but below the mouth of the Shell Rock the valley of the main stream becomes, and remains, broad and shallow in appearance, the borders which separate it from the uplands being indistinctly defined. The width of the river increases from 150 or 200 feet at Charles City, to 400 or 500 feet at Cedar Falls, and about 600 feet at Cedar Rapids. Its slope is given approximately in the following table:

Elevations and slope of the Cedar river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Cedar Falls†	845	124	73	1.70
Cedar Rapids‡	721	112	47	2.38
Moscow§	609	87	56	1.55
Mouth of Iowa river‖	522			

* Map measurement.
† River surface by Cedar Falls and Minnesota railroad levels.
‡ River surface by Chicago and Northwestern railway levels.
§ River surface at Chicago, Rock Island and Pacific railway crossing.
‖ Low water in Mississippi, by levels of Major Farquhar, connecting with lake Superior.

NOTE.—The elevations at Cedar Falls, Cedar Rapids, and Moscow are taken from *Geology of Iowa*, but with altitudes of datum planes corrected to agree with recent determinations.

a Also called Red Cedar river. Details given of improved powers on this river are as gathered by Mr. James L. Greenleaf, special agent.

The developed powers on the Cedar river are almost entirely devoted to the manufacture of flour, although at one or two principal points other branches of manufacturing are represented to a small extent. The lowest mill on the river is at Moscow, near the crossing of the Chicago, Rock Island and Pacific railway, in northern Muscatine county; it carries about three runs of stone, and has a cheap brush dam, yielding a head of 4½ feet. Between this point and Waterloo, in Black Hawk county, the only important improved power is at Cedar Rapids. There are two flouring-mills at other localities in Linn county and one or two in Black Hawk county, but from Waterloo to the mouth the river is claimed to be, generally speaking, poorly adapted to improvement, on account of its slight fall, width, and the lack of suitable sites. At Cedar Bluff, however, situated in the western part of Cedar county, 24 miles southeast of Cedar Rapids, there is said to be a very good location for developing a power, where, by backing the river up 10 or 12 miles, and building some side dikes to prevent overflow, a head of 10 feet may be obtained. The privilege is considered a valuable one, and the improvement of it has already been discussed somewhat. At present it suffers the disadvantage of having no established railroad less than 6 miles away. Cedar Bluff is a small village, with only about 100 inhabitants.

Cedar Rapids is an important city of 10,000 inhabitants, and the intersecting point of several prominent railway lines; it lies in the midst of a well-settled and fertile agricultural section. The Cedar river is there 500 to 600 feet wide, with low, gently-sloping banks, and a rocky bed, over which it runs in rapids. A framed dam of timber extends at right angles across the river, and forms a pond reaching 4 or 5 miles up stream, and partly covering the rapids. From either abutment a wooden guard-wall runs 75 or 100 feet along the side of the corresponding race. The race on the right-hand side of the river is short, and conveys water to a small foundery and machine shop using 20 horse-power; power has also been used on that side by an establishment for the manufacture of sash, doors, and blinds, but it has recently been washed away (previous to June, 1881), together with the adjacent guard-wall, thus causing a break through which the water pours, but which will doubtless be repaired.

On the left-hand side of the river is the principal employment of power. A race 35 feet wide conducts water to three flouring-mills and an oatmeal-mill, which was not, however, in operation when visited. These mills are located in a group along the race, and obtain a head ranging usually from 6 to 7 feet; it is even 8 feet at times, being highest when there is a fair stage of water in the river. In severe winters the flow of the stream is much diminished, but it is only in extraordinary seasons that the mills at Cedar Rapids are troubled by lack of water. There is, undoubtedly, a considerable waste of water at all times by leakage through various parts of the works. Difficulty on account of backwater is experienced usually for two or three days in spring, but the hindrance occurs only in high stages, and is of short duration, as the water is quickly carried off by the rapids below the dam. The ordinary freshet rise at the dam is said to be 4 or 5 feet above the average stage.

In the summer of 1880 a total of about 415 horse-power (*a*) was employed at this point. The available power is variously estimated at from 900 to 2,200 horse-power, with 7 feet head, in a low stage. It is certain that there is, under all ordinary circumstances, an important surplus power. By extending the race, and locating mills farther down stream, the head might be increased to perhaps 10 or 12 feet, advantage thus being taken of the rapids below the dam; but as the city is now built up the work of prolonging the race would be expensive. The entire power is considered as divided into sixty-four equal shares; the title to five of these is recognized by all parties as established, but that to the remaining shares is in dispute and litigation.

Estimate of power at Cedar rapids.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 7 feet head.	Theoretical horse-power, 10 feet head.
	Sq. miles.				
Low water, ordinarily dry year.....	6,543	640	72.7	509	727
Low water, average year		800	90.9	636	909
Available ten months in average year.		1,180	134	938	1,340

The next important power is at Waterloo, near the center of Black Hawk county. The neighboring country is rolling, and in many places covered with groves. The river is 500 to 600 feet wide, with banks 5 to 10 feet high. A timber dam about 550 feet long extends across the river at this point and sets it back, so that, in high stages, some difficulty is experienced from the backwater, at Cedar Falls, 7 or 8 miles above. The power at Waterloo is divided into twenty-four equal shares, of which twenty-three are owned by the Union Mill Company, and one by Messrs. Daniel & Slade. The Union Mill Company has a flouring-mill on each side of the river, using together about 300 horse-power. On the west bank Daniel & Slade's chair-factory employs a small power. On the same side a sash- and door-factory and a small woolen-mill use, respectively, 25 and 35 horse-power, which they rent from the Union Mill Company. An establishment for the manufacture of bee-hives is also returned as using 21 horse-power. Altogether about 400 horse-power is employed at this privilege. The ordinary working head is 5 feet.

a Rated power of wheels according to census enumerators' returns.

The mills are troubled by backwater a day or two in June, and in extremely cold winters are sometimes short of water. The dam is leaky, however, and it is thought that with a tight dam no difficulty would occur from low water. Commonly there is a large surplus power, which the proprietors are willing to rent. Waterloo has between 5,000 and 6,000 inhabitants, and is well situated, at the intersection of the Illinois Central and Burlington, Cedar Rapids and Northern railways.

Estimate of power at Waterloo.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 5 feet head.
	Sq. miles.			
Low water, ordinarily dry year	5,177	510	57.9	290
Low water, average year		630	71.6	358
Available ten months in average year		930	105.6	528

In the winter of 1881–'82 articles of incorporation were filed by the Waterloo Water-Power Company, with a capital of $300,000. This company proposed to develop a power in the south part of the city by throwing a dam across the river about 3,400 feet below the one I have described. From this dam a race, 100 feet wide, was designed to run 2 miles across a neck of land, emptying into the Cedar river again and rendering available a head of 7 feet. I have no further particulars concerning this enterprise, except that it was stated that work would probably be begun in the spring of 1882.

The first power above Waterloo is at Cedar Falls. The river is in that section 400 to 500 feet wide, with rather low banks. It makes a gradual bend to the eastward past the town, and on the upper part of this bend is the dam, a framed structure of timber resting on a rock bed. From the dam, the main race runs on the right-hand side of the river across the bend. Along this race, and on the side which is toward the river, are located a pump manufactory and an oatmeal-mill, in the same building, a woolen-mill (not running when visited), and a flouring-mill. The head increases from 5 feet at the dam to 8 or 9 feet at the lower mills. The dam sets the water back 3 miles up the river. The entrance to the main race is controlled by 12 gates, each about 5 feet wide, raised or lowered by levers. This race is, at the head, 70 feet wide and 4 or 5 feet deep; it continues of quite uniform width to the lower end, where it broadens to 150 feet.

The main race terminates in a timber dam 50 feet long, with abutments. From the right end of this dam a wooden flume conveys water some 30 feet to a bulkhead, surmounted by a tower, and containing 3 water-wheels. The power developed by these is transmitted distances of 50 to 200 feet, and runs a wagon-shop, foundery, and feed-mill. The main race is also continued in a smaller race, which carries water to a flouring-mill and novelty works (wood working); a second flouring-mill was burned, though the walls are still standing.

The power at this point is, with one or two minor exceptions, owned by the individuals using it, who are not incorporated, but merely united in an association in order better to maintain the works. Their rights are estimated in square inches of opening, under an average head of 9 feet. The various concerns own from 100 to 1,500 square inches each, or a total of about 6,000 square inches, which is considered to be the available capacity of the privilege in a low stage, with the present improvements. A total of about 400 horse-power is used here; it is claimed, however, that with proper improvements, and the use of the full head of 9 feet, the power can be doubled. There is abundance of room along the race for building, but the race itself is rather shallow, and by the formation of thick ice in winter the flow through it is much impeded. The dam is leaky, and by the cutting of a high-water channel around its end, on the left shore, where the land is low, a passage has resulted through which there is also at low water an important waste, thus lowering the head at the mills. Even under these circumstances they suffer very little from low water. In severe winters the supply sometimes decreases so that they have to compromise with each other, but such occurrences are rare. The working head varies about 1 foot, being highest in a fair stage of river. No serious trouble is experienced from backwater.

Estimate of power at Cedar Falls.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 9 feet head.
	Sq. miles.			
Low water, ordinarily dry year	4,720	460	52.2	470
Low water, average year		580	65.9	593
Available ten months in average year		850	96.6	869

There are no large developed powers above Cedar Falls, but there are numerous flouring-mills, the locations of all but one or two of which are herewith given, in order: Janesville, Waverly (two mills), Pearl Rock, Nashua, Charles City, Floyd, Osage, Mitchell, West Mitchell (woolen-mill), Saint Ansgar, Newburg, Otranto Station, and Otranto. All these are below the Minnesota boundary. They carry from three to seven runs of stone each, and have heads ranging from 5 to 10 feet, the average being 7½ feet.

At Charles City the river is 200 feet wide, and a framed dam of timber filled with stone has been built across it, creating a head of 10 feet. The privilege is occupied by a seven-run flouring-mill, which uses about half the power of the river at a low stage. It was stated as probable that a paper-mill would also be erected; if so, it could easily be supplied with straw from the surrounding section. The river here rises about 4 feet above low water, usually in June, and runs lowest in mid-summer or in a cold winter. Below the dam are rapids, with a fall of 4 or 5 feet in 2,000 feet. There is no unoccupied power between Charles City and Floyd, but a privilege could probably be developed below the former point. Passing up stream into Minnesota, there are found to be five flouring-mills in Mower county of that state, with heads ranging from 7 to 13 feet; the highest mill is probably one at Ramsey.

All along its course the Cedar receives, at intervals, little streams, such as Rock, Indian, Spring, Wolf, Black Hawk, Beaver, and Big creeks, and Little Cedar river, which sustain from one to four flouring- and grist-mills each. (*a*) The only important tributary, however, is Shell Rock river, which has already been alluded to.

SHELL ROCK RIVER.

This stream has its main source in Albert Lea lake, some 8 or 10 miles above the Minnesota boundary. It runs southeasterly for about 80 miles by general course, and 6 miles northwest of Cedar Falls, Iowa, unites with the main river. It drains an area of 2,631 square miles, having a slightly undulating surface and a comparatively thin covering of Drift.

Elevations and slope of the Shell Rock river.*

Locality.	Elevation above sea.	Fall between points.	Distance between points. †	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Rockford Station ‡	1,023	117	35	3.34
Shell Rock village ‡	906			
Cedar Falls (main river) §	845	61	15	4.07

* Taken from *Geology of Iowa*, with altitudes of datum planes corrected.
† Map measurement.
‡ By railroad survey.
§ River surface by Cedar Falls and Minnesota railroad levels.

As indicated by the rate of its descent, the Shell Rock is quite a rapid stream. There are numerous mills along its course, but many unutilized sites still remain. These are not all, however, equally suited to improvement. Thus, at Clarksville and vicinity the banks are low and considerable difficulty is experienced on that account. Ten miles up stream the bed is sandy, and the dam at Greene is constructed on piles; while at Rock Falls, in Cerro Gordo county, the site is excellent. The mills on the stream are located as follows, in succession from the mouth: Finchford, Shell Rock (two mills), Clarksville (two mills), Greene, Marble Rock, Rockford, one between Rockford and Nora Springs, Nora Springs, Rock Falls, Plymouth, one 3 or 4 miles above Plymouth, Northwood, and finally one at the outlet of Albert Lea lake. Most of these mills carry from two to four runs of stone each, and some are also provided with rollers; they have an average head of about 8½ feet.

The Shell Rock receives, in turn, two principal tributaries—West Fork and Lime creek; the former drains 858 square miles, and the latter 641 square miles. Lime creek rises in northern Winnebago county, close to the Minnesota line. It runs southerly and then southeasterly, and joins the Shell Rock at Rockford, in Floyd county. Above Fertile it is rather sluggish, but thence to the mouth, and especially below Mason City, it is very rapid in places. There is a flouring-mill at Rockford, one 4 miles below Mason City, and there are three or four above the latter point. There are also said to be many good sites for power still unimproved.

At Mason City Lime creek receives, through Willow creek, the drainage of Clear lake, which is located in the western part of Cerro Gordo county. This lake is described by Dr. White as being about 5 miles long, 2 or 3 miles broad, and having a maximum depth of 15 feet. Its shores are gravelly, and its banks mostly wooded. There is a two-run mill on the outlet. The lake yields ordinarily a very steady supply of water, but it is said to have fallen so low on one occasion that the privilege on the outlet was valueless for a year.

a Drainage area of Wolf creek, 321 square miles; Black Hawk creek, 366 square miles; Beaver creek, 410 square miles; Little Cedar river, 311 square miles.

Estimated volume and horse-power of the Cedar river and tributaries.

Stream and locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Cedar, at Charles City	989	70	80	90	102	130	148
Cedar, at Waverly	1,538	150	170	190	216	270	307
Cedar, at Cedar Falls	4,720	460	523	580	659	859	966
Cedar, at Waterloo	5,177	510	579	630	716	930	1,056
Cedar, at Cedar Rapids	6,543	640	727	800	909	1,180	1,340
Cedar, at Cedar Bluff	7,028	690	784	860	977	1,260	1,431
Cedar, above junction with Iowa river	7,715	740	841	920	1,045	1,350	1,534
Shell Rock, at Rockford, above Lime creek	621	60	68	80	91	110	125
Lime creek	641	60	68	80	91	110	125
West Fork	858	80	91	100	114	150	170
Shell Rock, at mouth	2,031	250	284	320	364	470	534

THE SKUNK RIVER.

This stream rises in Hamilton county, in the central part of Iowa, whence it runs southeasterly and, after forming the boundary between Des Moines and Lee counties, empties into the Mississippi. It is 200 miles long, by general course, with a drainage area of 4,409 square miles; the width of this area is for the most part quite uniform, ranging from 20 to 30 miles. The country has a rolling surface, well suited to agriculture, and along the lower river is moderately well supplied with hard-wood timber. Railroad lines cross the river and its basin at many points, but usually at so large an angle as to afford but limited facilities to the immediate course of the stream. Along the latter there are but few important towns; the more prominent, in order from the mouth, are Mount Pleasant (3 miles from river), population about 4,400; Brighton, in Washington county, 800; Colfax, in Jasper county, 700; and Ames, in Story county, 1,200.

Elevations and slope of the Skunk river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Southeast part of Hamilton county †.	1,056	149	21	7.10
Near Ames, Story county †	907	148	36	4.11
Vowell's, Jasper county ‡	759	209	108	1.94
Rome, Henry county §	550	45	38	1.18
Mouth of river‖	505			

* Map measurement.
† Water surface at Chicago and Northwestern railway crossing.
‡ Water surface at Chicago, Rock Island and Pacific railway crossing.
§ Low-water surface at Chicago, Burlington and Quincy railroad crossing.
‖ Low water in Mississippi river, by levels of Major Farquhar, connecting with lake Superior.

NOTE.—Elevations at Vowell's and at Rome are from *Geology of Iowa*, with altitudes of datum planes corrected.

The upper course of Skunk river lies over the Middle and Lower Coal Measures, but below the junction of the North and South Forks it runs along the border between the exposures of those formations and the sub-Carboniferous. The principal outcroppings of rock occur in the lower valley, especially in Henry and Des Moines counties, and consequently it is on the lower half of the river that the best mill-sites are to be found. The valley of the stream is, generally speaking, broad and flat, with gently-sloping sides, and covered with a rich, deep clayey soil. Along the lower course the bottom-land averages about 2 miles in width, but occasionally disappears where the bluffs approach simultaneously from either side. In addition to the first, and lowest, bottom, which is immediately beside the stream, there are generally to be discerned one, and even two, higher bottoms, or terraces, farther back. In this section the river bed is rocky; the banks are mostly of loam, with some rock exposures, and average 10 feet or more in height above low water. The lowest stage commonly occurs in August and September. The river is subject to great and rapid rises, during which the bottoms, and especially the first bottom, are seriously overflowed. These freshets, however, are said to have considerably decreased in magnitude of late years.

In the southeastern part of Keokuk county the South Skunk, or main river, is joined by the North branch, which drains a little less than half the area that the former does at their point of junction. Thence to the Mississippi, and above on both forks, there are many flouring-mills; they are mainly found below the northern limit of Mahaska county, there being but two or three on both streams above. From the western boundary of Henry county to the mouth the fall appears to be nearly all taken up, but above Henry county a considerable amount still remains open to improvement. So far as I could learn, the mills on the lower river are located as follows, in order from the mouth: Augusta, Bridgeport, Lowell (two mills), Boyleston, Otter Mills, Oakland, Star Mills, Merrimac, and Washington; the positions of those farther up stream may be sufficiently judged from the summary by counties, appearing in a subsequent table. The mills mentioned are all flouring-mills, and carry about three runs of stone each. The dams are generally framed structures, and furnish heads ranging from 4½ to 8 feet. It is said that the mills can, on the average, run ten months in the year at full capacity, but are troubled one month by low water, and one month by backwater; the Oakland mill suffered from backwater seven weeks during the spring of 1881. The privilege occupied by this mill is improved by a framed dam 325 feet long, 9 feet high, filled with stone and planked over. The head on the wheels varies from 5½ to 8 feet, but averages about 7 feet. The mill carries four runs of stone, and the proprietor roughly estimates that, with 6½ feet head, his privilege would carry fifty runs of stone for eight months in the year. A small woolen-mill of two sets has been in operation here, but was not running at the time of my visit. The chief obstacles to the establishment of woolen manufacturing in this section are described as being a lack of capital, and difficulty in obtaining good workmen.

The Skunk river is 300 to 400 feet wide in the vicinity of Oakland. Although it is a tolerably good stream, and furnishes power to many mills, it has not that steadiness of flow which characterizes the Cedar and Iowa, to the north; it is, in fact, quite unreliable, and while there will sometimes be an abundance of water for two successive years, in the third year it is liable to run very low.

Besides the North Fork, the most important tributary, this river receives in western Henry county Big Cedar creek, having a drainage area of 520 square miles, but unused for power except by one small saw-mill; and in Jasper county, from the east, Indian creek, draining 336 square miles, and having two flouring- and grist-mills of small size.

Estimated volume and horse-power of the Skunk river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Cambridge	726	40	45	60	68	80	91
Vowell's	1,275	80	91	100	114	150	170
Farmersville	1,654	100	114	130	148	200	227
Below North Skunk	2,745	170	193	220	250	330	375
Rome, below Big Cedar creek	4,037	240	273	330	375	490	557
Mouth of river	4,400	270	307	360	409	530	602
North Skunk, at Union Mills	444	20	23	40	45	60	68
North Skunk, at mouth	862	50	57	70	80	110	125

THE DES MOINES RIVER AND TRIBUTARIES.

The largest, and, in some respects, the most important, stream in Iowa is the Des Moines. Its source is in southwestern Minnesota, near the boundary between Lyon and Murray counties; it runs thence, in a generally southeasterly direction, across the state of Iowa to the Mississippi. It has a length, by general course, of 370 miles, for the last 23 of which it forms the boundary between Iowa and Missouri. At Des Moines its general direction changes to the eastward by something less than 30°, but either way from that point is quite straight; thus, if a straight line be drawn from the locality where the stream enters Iowa to Des Moines, and another from Des Moines to its mouth, its course, though showing many minor bends, will be nowhere distant more than 8 miles from the adjacent air-line.

The basin of this river comprises an area of 14,578 square miles, about 70 per cent. of which lies above Des Moines; its width is greatest in the upper part, and decreases from 75 or 80 miles at Fort Dodge to 50 miles at Des Moines and 20 miles at Ottumwa. The surface is a fertile, rolling prairie, quite flat in some sections, as toward the upper waters of the Raccoon; there is very little timber, except toward the mouth of the river, and even there what formerly existed has been largely cut away. Above the latitude of Des Moines there are to be found, scattered over the surface, many ponds of insignificant size, and in the upper basin a few lakes of some importance; the larger of these are Storm lake, with an area of about 7 square miles; Palo Alto, 6 square miles; Okamanpadu,

8½ square miles, and Heron lake (Jackson county, Minnesota), 11 square miles. (*a*) Okamanpadu and Heron lakes have visible outlets, but Storm and Palo Alto lakes appear isolated, though they doubtless contribute by percolation to neighboring water-courses; they are all of Drift origin, and are characterized by gravelly beds and shores, clear and rather shallow waters.

Not only does the area drained by the Des Moines possess fine agricultural resources, but in the vicinity of Fort Dodge there is a deposit of gypsum, said to be one of the most important in the United States and the only one of economic value in Iowa or the surrounding states; while, from below Fort Dodge to the mouth of the river, and covering nearly all that portion of the basin, stretch the Iowa coal-fields. The coal is bituminous, of good quality, and has already been mined at many points, mainly where exposed on the sides of the creek and river valleys. (*b*)

The railroad facilities of the Des Moines basin are, generally speaking, good, since it is traversed by a considerable number of important lines; but so far as concerns the development of water power they are of the most value on that part of the river below Mahaska county, for thence to the mouth the stream is closely followed by the Keokuk and Des Moines railroad; above Eddyville this road is distant 5 to 10 miles from the river on the north. For some 25 miles north of Fort Dodge the Minneapolis and Saint Louis railway also follows the main course of the river. At numerous other points it is approached or crossed by railway lines, but they have usually an east-and-west direction, and so traverse the valley at a considerable angle from its general direction.

The lower valley is the most thickly settled portion of the section we are considering, but in recent years, with the building of new railroads, the upper basin has attracted a considerable immigration. The population of the entire basin increased in the ten years previous to 1880 from about 237,000 to 349,000. The larger towns, in order as we ascend the river, are: Keokuk (near the mouth, on the Mississippi), population about 12,100; Bonaparte, 700; Keosauqua, 900; Eldon, 700; Ottumwa, 9,000; Eddyville, 900; Oskaloosa (6 miles from the river), 4,600; Pella (3 miles from river), 2,400; Knoxville (5 miles from river), 2,600; Des Moines, 22,400; Moingona, 1,000; Boonesboro', 3,300; Fort Dodge, 3,600; Emmetsburg, 900.

Elevations and slope of the Des Moines river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Windom, Minnesota †	1,329			
		365	111	3.29
Fort Dodge, Iowa ‡	964			
		43	31	1.39
Southeast part of Webster county §	921			
		44	24	1.83
Moingona §	877			
		91	40	2.27
Des Moines ‖	786			
		150	111	1.35
Ottumwa ¶	636			
		160	94	1.70
Mouth of river **	476			

* Distances above Des Moines are by map measurement; those below are by an old survey of the river.
† Water surface at Chicago, Saint Paul, Minneapolis and Omaha railway crossing.
‡ Water surface at Illinois Central railroad crossing.
§ Water surface at Chicago and Northwestern railway crossing.
‖ Water surface at mouth Raccoon river, based upon old survey.
¶ Water surface below dam, based upon old survey.
** Low water in Mississippi river, by survey of Major Farquhar connecting with Lake Superior.

Eleven miles north of Fort Dodge the West Fork, or main river, is joined by the East Fork. The country drained by them is gently rolling. Their valleys range from a few hundred yards to half mile in width, and are depressed 50 to 150 feet below the general level of the surrounding uplands, to which there is a gradual rise. Their beds are more or less gravelly, but the banks are muddy. At Fort Dodge the depth of the valley is about 170 feet below the uplands, and is seldom exceeded at points farther down the river. From Fort Dodge to Amsterdam, in Marion county, the Des Moines runs through and upon the Lower Coal Measures, but natural exposures of these seldom occur in the valley, because of the deep overlying Drift. The bottom-land is in this section an eighth to a half mile wide, while the valley sides are irregularly sloping, and sometimes abrupt. Concerning that part of the river below Amsterdam, I quote from the *Geology of Iowa*:

> From Amsterdam to Ottumwa the sub-Carboniferous limestone appears at intervals in the valley sides again, forming low cliffs occasionally; but the exposures are generally small and distant from each other. Near Ottumwa the sub-Carboniferous rocks pass beneath the river again, bringing down the Coal Measure strata into its bed, but they rise again from it in the extreme northwestern corner of Van Buren county, and sub-Carboniferous strata resume and keep their place along the valley from there to the mouth of the river.

a These areas are as measured by planimeter on land-office maps.

b According to the Iowa *Agricultural Report* for 1879 there was mined in the state, during that year, 62,500,000 bushels of coal, of a value of $5,000,000.

The Des Moines river is not now a navigable stream, but some thirty years ago an attempt was made by the state of Iowa to establish slack-water navigation between the mouth and Des Moines city. (*a*) The original design contemplated a system of twenty-eight dams, with accompanying locks; two additional locks were to be provided in canals, of which 29.46 miles were to be excavated in order to shorten the river's course. The entire elevation to be overcome was about 310 feet, and the length of navigation to be secured 183.85 miles. By an act, approved August 8, 1846, Congress granted, in aid of the enterprise, 321,800 acres of public lands lying along the river below Raccoon Forks; subsequently, another grant of 1,000,000 acres, situated above Raccoon Forks, was made. Work was begun upon the lower river, and carried on at intervals between the years 1851 and 1856. At length, however, the general government refused to recognize the grant of 1,000,000 acres above Raccoon Forks, and work was permanently suspended. The water-privileges which had been developed by the building of dams were sold.

When work ceased upon the improvements, locks and dams had been completed at Croton, Bonaparte, and Bentonsport, and the lock-walls and abutments for the dam had been constructed at Keosauqua. Although work had been undertaken at other points also, no permanent structures had been built. The three dams were of crib-work, but, with the exception of that at Bonaparte, have since been carried away. The abutments and lock-walls were built of heavy limestone masonry, and still remain in fine condition.

That portion of the river below Des Moines, and, in particular, that part between Ottumwa and Croton, presents great advantages for development of water-power on an important scale, on account of the large volume and the generally favorable character of the bed and banks. There are numerous rock exposures, and from Ottumwa to Croton the bed is a smooth, even surface of limestone, while the banks are in the same distance of good height, averaging 20 feet above low water. In the vicinity of Bonaparte the bottom-land is quite narrow, not more than half a mile wide on the average, and in places steep rocky bluffs rise abruptly from the river on each side. The width of the stream increases from less than 400 feet below the mouth of the Raccoon to 500 feet near Ottumwa, and 600 feet in the vicinity of Bonaparte. Above Ottumwa the river banks are rather low, and the bottom-land is 1 mile to 2 miles in width. Below Saint Francisville the stream is meandering, with low banks and sandy bed.

The portion of the river we are now considering has a good current and a quite steady flow. The highest freshets occur in June, a month of heavy rains, but high water is also caused in spring by melting snows. The river banks, in the lower portion of its course at least, are seldom overflowed. The ordinary June rise in this section is 8 to 10 feet. The greatest recorded floods in the history of the river were those of 1851 and 1858, during the former of which years the rise in the lower river was 25 feet. At times, during high water, the Des Moines transports large amounts of drift, though no damage results from it. The greatest sources of trouble to the dams are the heavy runs of ice; the dams at Keosauqua and Bentonsport, and a part of the dam at Croton, have been carried away by this means. In view of this fact, and the size of the river, it is evident that improvements must be substantial and expensive.

Following is a list of the dams, with their locations, height, and lift, which were formerly designed for the purposes of slack-water navigation between the mouth and Ottumwa. They were all so planned as to position and height as to rest either wholly or in part upon rock foundation, and to cause but little overflow by backwater. Although the sites mentioned might not now be chosen for water-power improvements, still the table exhibits the localities at which it is practicable to obtain certain falls, as shown by actual survey:

Dams formerly planned to secure slack-water navigation in the Des Moines river below Ottumwa.

Location.	Height of dam.	Lift of lock.	Locality where fall, assumed equal to lift of lock, would be available.
	Feet.	*Feet.*	
No. 1, Saint Francisville	.....	32.0	Available by canal on north side from dam to mouth of river, a distance of 12 miles; 10 feet to be secured at lock 6 miles from dam, and 22 feet at guard-lock at end of canal (at low water in Mississippi).
No. 2, 7.25 miles by river above Saint Francisville	14.0	10.0	Available at dam.
No. 3, Croton	14.0	10.3	Available at dam; 8 feet now in use.
No. 4, 1 mile above Farmington	15.0	11.5	Available at dam.
No. 5, Bonaparte	11.0	7.5	Available at dam; 8 feet now in use.
No. 6, Bentonsport	15.0	12.3	Available at dam; 7 feet has been in use.
No. 7, Keosauqua	15.0	11.8	Available at dam; 11 feet has been in use
No. 8, 8.4 miles above Keosauqua	14.0	11.0	Available at dam.
No. 9, 6.4 miles below Iowaville	15.5	12.5	Do.
No. 10, 1.1 miles above Iowaville	15.5	12.4	Do.
No. 11, 8.25 miles above Iowaville	10.5	7.5	Do.
No. 12, 8 miles below Ottumwa	10.0	6.0	Do.
No. 13, 4 miles below Ottumwa	10.5	7.5	Do.

The first improved power met in ascending the Des Moines is opposite Croton, Lee county, Iowa. With the exception of 100 feet at each end, the upper crib-work of the old state dam at this point still remains; the rest has

a The reports of the improvement company and a profile of the river were procured for me through the efforts of Dr. J. M. Shaffer, of Keokuk.

been rebuilt of brush, with rock ballast. It rests upon a solid limestone bed, is 700 feet long and about 50 feet wide at the base. The masonry abutments are stated to be in good condition on both sides of the river; on the Iowa side, the head and shore walls of the lock are yet standing, but one-half of the river wall has been washed away. Power was formerly used on that side by a four-run flouring-mill and a saw-mill, but they were carried away by ice in 1866. On the Missouri shore there is now a two-run flouring-mill, using a head of 8 feet. Mr. S. P. Gray, of Croton, owns the privilege on the Missouri side, and would like to sell a portion of it.

Estimate of power at Croton.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 8 feet head.
	Sq. miles.			
Low water, ordinarily dry year	14,385	1,110	126.1	1,009
Low water, average year		1,300	147.7	1,182
Available ten months in average year.		1,950	221.5	1,772

The next power is at Bonaparte, where the river has a width of 500 to 600 feet, a depth of 2 to 3 feet in an ordinary stage, and a good current. The state formerly built a dam at this point, which yet stands with the exception of the apron. As first built it consisted of a timber crib-work, filled in with stone, with a width of 20 feet at the base; it was supplemented by two successive low cribs on the down-stream side, forming offsets of 10 feet each, and together constituting an apron for the protection of the river bed. The effect of heavy ice running over the dam was to tear up the planking of the apron, and so destroy that portion, leaving only the main crib-work, having a base of 20 feet. In 1873 a new dam was constructed immediately below this, at a cost of $8,000 to $10,000. It is 666 feet long between abutments, and is similar in construction to the old dam above it; it is 18 feet wide at the base, 10 feet high at the crest, and 6 to 7 feet high at the back. It rests upon a limestone bed, and on the south side abuts against a timber and stone crib, while on the north side the wall of the old lock serves as an abutment. At the back of the dam is driven a double row of sheet-piling, and the remaining space to the breast of the old dam is packed with gravel. The new structure has no apron, and in consequence the overflow of the water has already worn some 2 feet into the river bed. The dam which I have described has given good satisfaction, and has withstood heavy runs of ice without injury. The pond extends 4 miles up the river. The head on the wheels is 8 to 8½ feet, and no trouble is experienced from backwater.

The Bonaparte power is owned by Messrs. Meek & Brothers, who run in connection with it a woolen-mill, a flouring-mill, and a small saw-mill. The woolen-mill was started in 1854, subsequently burned, and rebuilt in 1863. It carries six sets of cards and some other machinery, and gives employment to 75 or 80 hands. Cassimeres, blankets, jeans, and yarns are manufactured, and sold mainly in Iowa. The flouring-mill has five runs of stone. About 160 horse-power is used at this privilege, and the proprietors consider the supply of water sufficient, in the lowest stage, for at least three or four times that amount.

The first power above Bonaparte is that at Bentonsport. The dam, which stood until recently, was a crib-work structure filled with stone; it was 600 feet long, 24 feet wide at the base, 12 feet high at the breast, and 5 feet high at the back. It was owned by non-resident parties, who took but little interest in keeping it in repair; the timbers were alternately wet and dry, rapidly decayed, and the dam was very leaky; finally, during the winter of 1880–'81, it was carried away by the run of ice. The pond set back probably 6 to 8 miles, and a head of 7 feet was obtained. Mills were located on both sides of the river as follows:

	Horse-power.
On south side:	
One woolen-mill, two sets, about	35
One flouring-mill, four runs, about	48
On north side:	
One woolen-mill, (*a*) two sets, about	35
One flouring-mill, four runs, about	48
One paper-mill, (*a*) about	24
One saw-mill, about	20
Total power used, about	210

There was a scarcity of water for these mills in the dry season, but this was due solely to the leaky condition of the dam. At the time of my visit, in June, 1881, no repairs had been attempted, but the citizens of Bentonsport had formed a joint stock company, and a plan had been prepared for a new dam, (*b*) to cost about $10,000. It was thought that the work of construction would soon be under way. The proposed dam is to be a framed structure, consisting of bents 7 feet apart, each bent having four vertical posts, 7½ to 8 feet apart from center to center, set

a Mill had ceased operations before the date of the dam giving way. *b* See page 103.

into the rockbed at the base and properly braced. The dam will have a width at the base of about 24 feet, the crest rising 13 feet above the foundation; the top will be heavily planked, and slope up stream to the back, which is to have a height of 4 to 4½ feet above foundation. The interior of the dam will be packed with loose stone, and faced at the breast with 9 or 10 inches of concrete filling, contained between planking. The river bed is of limestone, and very favorable to the security of a well-built dam. The masonry abutments, built long ago by the state, remain in good condition. I was informed that upon the completion of the new dam the two flouring-mills would resume operations. It was desired to attract new enterprises to this point, and, to such, inducements would be offered which would probably include free rent and taxes, and possibly other aid. Bentonsport is a small place of 300 inhabitants, on the Keokuk and Des Moines railroad. There is a ferry running across the river, but no bridge.

Estimate of power at Bentonsport.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 10 feet head.
	Sq. miles.			
Low water, ordinarily dry year	14,197	1,090	123.8	1,238
Low water, average year		1,280	145.4	1,454
Available ten months in average year		1,920	218.1	2,181

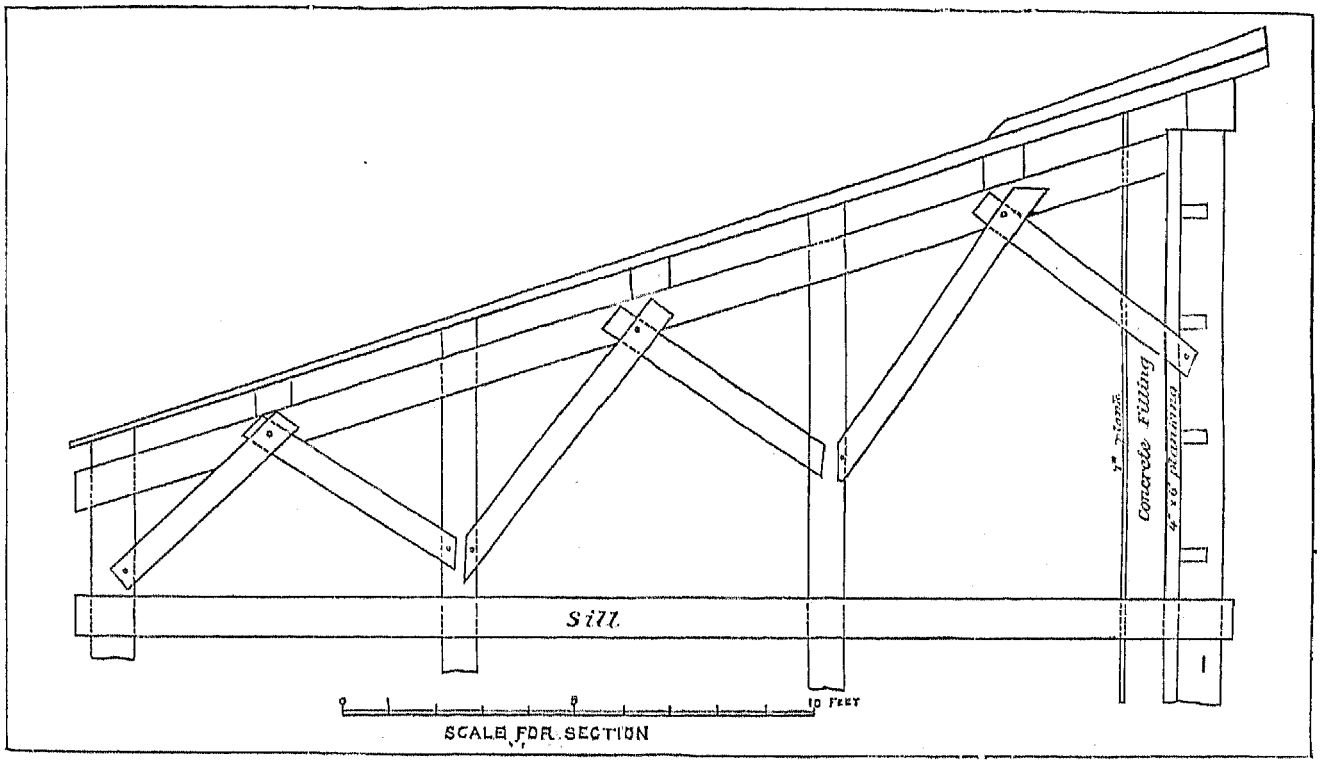
The Keosauqua power is the next in order. The town is very prettily situated on a bend in the river, and is connected with the Keokuk and Des Moines railroad by a short branch. In 1870 a crib-work dam was built across the river, but the workmanship was poor, the base was made altogether too narrow in proportion to the height, and in January, 1880, the structure was carried away in fifteen minutes after the ice started to run out. It had furnished a head of about 11 feet, and supplied power to a flouring- and grist-mill, of three runs, owned by Messrs. Wilson & Lee. These gentlemen, not being in a position to rebuild the dam in a substantial manner, have put steam-power into their mill. They would be very glad, however, to see the water privilege improved, and would offer strong inducements to secure that result. A new dam would need to be about 600 feet long. It would have for foundation a solid limestone bed, and for abutments the heavy masonry formerly built on each side of the river by the state, and which now stands in fine condition.

Estimate of power at Keosauqua.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 11 feet head.
	Sq. miles.			
Low water, ordinarily dry year	14,154	1,090	123.8	1,362
Low water, average year		1,280	145.4	1,599
Available ten months in average year		1,920	218.1	2,399

At Ottumwa somewhat of a manufacturing center has been established. A joint stock company was formed by the citizens of this place, and in 1875 the construction of two dams across the river, one on each side of Turkey island, was begun. The original contract price for dams, canal, and accompanying works was $64,000, plus an allowance per cubic yard of excavation. Disputes arose regarding the payment of the contractor, but a settlement was finally effected for about $64,000. The contractor is said to have left the dam, and, indeed, the whole work, in a very poor and incomplete condition. The west dam was a crib-work, filled in with sand and gravel, and was not properly protected by planking. The coffer-dam of brush, which had been built above the permanent structure, was left in place, and in January, 1877, not long after the work was turned over by the contractor, the water pouring over the brush coffer rapidly wore out the filling of the dam below, and about 40 feet of it was carried away. In the fall of 1877 the dam was repaired, and then stood for one year, when it had to be entirely rebuilt. In order to meet the various expenses arising, considerable sums of money have been advanced, on the security of the works, by eastern parties, and the total expenditure connected with the enterprise now amounts to about $120,000.

The west dam is now ballasted with stone, and has an apron of the same construction as its own. The east dam is also a crib-work. Both are of about the same height, and each is 350 feet long. They rest upon a firm rock bottom, and are protected at the ends by substantial abutments of masonry. From above the dams a large main race, 4,300 feet long, runs in a southeasterly direction, across the neck of a bend in the river, to the mills, and terminates in a bulkhead. Twelve hundred feet below the upper entrance to the race there is a guard-



DAM AT BENTONSPORT.

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lock, or bulkhead, measuring 200 feet across the race, and built of masonry. The river brings down considerable sediment, which enters the race between the dam and guard-lock and forms a troublesome deposit. The full head attainable at the mills is 10 feet, but only 8 to 8½ feet is now available, and no more will be till a small amount of blasting shall be done in the tail-race. The following concerns are supplied with power, some of them also using steam: Ottumwa Cutlery Company, City Water Works, Ottumwa Starch Works, Johnson Ruffler Company, Ottumwa Iron Works, an oil-mill, and a flouring-mill. About 275 horse-power of water is used in all. (*a*) There is always an abundance of water, and the theoretical power of the river at this point, with 10 feet head, and in a medium stage, has been estimated at 3,000 horse-power. My own estimate of the power at lower stages is given below. For a short time in the year the mills are troubled by backwater. They are conveniently situated, and close at hand are the tracks of the Chicago, Burlington and Quincy, and Chicago, Rock Island and Pacific (Keokuk and Des Moines division) railroads. Mr. S. L. Wiley now holds the property pertaining to the water-power, as trustee. No regular rate is established for the use of water, and the affairs of the company were in such condition at the time of my visit that no inducements could be held out to manufacturers, nor were any efforts being made to attract them to this point.

Estimate of power at Ottumwa.

Stage of river.	Drainage area.	Volume, cubic feet per second.	Theoretical horse-power, 1 foot head.	Theoretical horse-power, 8 feet head.	Theoretical horse-power, 10 feet head.
	Sq. miles.				
Low water, ordinarily dry year	13,465	1,040	118.1	945	1,181
Low water, average year		1,210	137.5	1,100	1,375
Available ten months in average year		1,820	206.8	1,654	2,068

Above Ottumwa there is a flouring-mill on the Des Moines, with 5 feet head, in Marion county, and another at the city of Des Moines. The dam at the latter point was built in 1862, before there were any railroad facilities here, and when the iron for it had to be brought by teams from Keokuk. The foundation is part of the way sand, and part a shaly rock. This dam is 600 feet long, 5 feet high, and consists of crib-work filled with stone, with abutments of similar construction. The bottom logs are anchored to the rock bed, and the upper ones are bolted to these. Messrs. Serrin & Fairbanks own one-half the privilege, and have a flouring-mill at one end of the dam. The mill carries four runs of stone, and uses a head of 5 feet, though by charter the privilege is entitled to 9 feet head. The location is a fine one, but the title is at present so involved in litigation that no attraction is offered for the establishment of new concerns. It is said that parties have been, and are, ready to utilize the power so soon as matters shall be righted.

Above Des Moines there is no power in use on the river before reaching Humboldt county, but from that section there are flouring-mills, at intervals, well on toward the source in Minnesota. Above the mouth of the East Fork there is said to be a good unimproved privilege below Humboldt, and another at Petersen, in the southwestern part of Emmet county. In Humboldt county the river runs 100 to 125 feet wide, and is claimed to be capable of carrying six runs of stone, with 7½ feet head, nine months in the year, and four runs all the time, except in very dry seasons or unusually cold winters; in the latter case, very thick ice forms, and there is but little water running.

Below the mouth of the East Fork, and for a considerable distance below Fort Dodge, the river is 200 to 250 feet wide, with rather low banks. The bed is largely Kinderhook limestone, the strata of which dip to the southwest at a somewhat greater pitch than that of the river. The latter has a moderate fall, without important rapids, and numerous water privileges may be found, with an available head of 6 or 8 feet; dams of greater height would be likely to cause overflow of the banks. The river bed in this section contains many springs, which preserve open spots in the ice during winter, long after the rest of the stream is frozen over, and are resorted to by wild fowl. Corn and stock are the principal exports of the country about Fort Dodge. It does not appear to be so well adapted to winter wheat as that farther south, or to spring wheat as that to the north, in Minnesota. Flax is a successful crop, and its production is increasing. Bituminous coal, brick-clay, and building-stone of fair quality, are obtained at Fort Dodge, in addition to gypsum from the valuable deposits.

a Seventy horse-power of steam is also employed.

Estimated volume and horse-power of the Des Moines river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Below Heron lake outlet	979	50	57	60	68	80	91
Emmetsburg	1,706	90	102	110	125	170	193
Below East Fork	3,951	250	284	300	341	440	500
Fort Dodge	4,537	290	329	340	386	510	579
Boonesboro'	5,010	400	454	460	523	700	795
Above Raccoon river	6,672	470	534	550	625	830	943
Below Raccoon river	10,000	740	841	860	977	1,300	1,477
Below Middle Three river	11,120	840	954	970	1,102	1,460	1,659
Bennington	11,822	900	1,022	1,050	1,193	1,580	1,795
Ottumwa	13,465	1,040	1,181	1,210	1,375	1,820	2,068
Keosauqua	14,154	1,090	1,238	1,280	1,454	1,920	2,181
Mouth of river	14,578	1,130	1,284	1,310	1,488	1,970	2,238

NOTE.—It should be borne in mind that the volumes as here estimated are the average for the twenty-four hours, and are independent, therefore, of storage in mill-ponds.

With the exception of Boone river and the East Fork, the Des Moines receives no important accessions from the east side. The principal tributaries, in order from the mouth, are as follows:

Tributaries of the Des Moines river.

Stream.	Drainage area.	Stream.	Drainage area.
	Square miles.		*Square miles.*
Cedar creek	425	Raccoon river	3,020
White Breast river	410	Beaver creek	410
South river	606	Boone river	800
Middle Three river	592	East Fork	1,357
North river	374		

RACCOON RIVER.

This stream is the largest affluent of the Des Moines, which it joins at the city of Des Moines. The main fork takes its rise in Buena Vista county, whence it runs in a southeasterly direction, and in Dallas county is joined by the South Fork. The Raccoon river has a total length by general course of about 125 miles. The country drained by the North Fork is gently rolling, becoming quite flat in the upper basin. In that section the river drains numerous small lakes, varying from 1 to 40 acres in extent, and some of larger size. Once in a few years it happens that, owing to continued heavy rains, these lakes get very full and prolong a high-water stage in the river for several months. This branch flows through bottom-land ranging from a mile to a mile and a half in width. The bed is in part sand, and in part a hard blue clay, which affords a fine foundation for dams. About 50 per cent. of the banks are estimated to be bluffy; elsewhere they average 10 to 12 feet in height. The stream is rather crooked, and at Adel is said to make a long bend of 7 miles, the distance across the neck of which is only 1 mile. In a medium stage the North Fork is 100 to 125 feet wide, and 6 to 10 feet deep in the eddies; shoals occur once in half a mile or a mile, where the depth is perhaps 2 feet. The flow is quite steady, though occasionally in winter the stream runs very low. The current is somewhat sluggish compared with that of the South Fork, and the mills on its course are troubled by backwater about one month in the year. The stream has a gradual rise and fall, but both the North and South Forks overflow their banks on the average once in every alternate year.

The South Fork—and the characteristics of the Middle Fork are about the same—flows through a rougher country than the stream I have just described, and its banks are more bluffy than those of the latter. The bottom-lands are of about the same width on both branches, and the streams themselves are approximately equal in size. The South Fork, however, is straighter, less deep, has a more rapid current, and shoals more frequently. There is but little trouble on this stream from backwater. It has a rocky bed, is subject to sudden rise and fall after heavy rains, but, being largely fed by springs, has a well-sustained volume in the dry season.

The country drained by the Raccoon and its branches is not, as yet, thickly settled, but it is intersected by several railway lines and is increasing in population. I was informed by a gentleman familiar by long experience with both streams, that neither the North nor the South Fork is yet improved to more than 50 per cent. of its capacity, although they are employed for power by a considerable number of flouring-mills. The dams are reported to have stood well; they are commonly of crib-work, filled with brush and stone. The mill at Adel, on the North Raccoon, is situated on a slough, into which water is diverted from the river by a low rude dam; it has a head of 12 feet, and carries four runs of stone.

Elevations on the North and Middle Raccoon rivers.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
NORTH RACCOON.	*Feet.*	*Feet.*	*Miles.*	*Ft. per mile.*
West of Newell†	1,246	246	67	3.67
West of Jefferson‡	1,000			
Des Moines§	786	214	66	3.24
MIDDLE RACCOON.				
Carroll Station‖	1,276	490	93	5.27
Des Moines¶	786			

* Map measurement.
† Water surface at Illinois Central railroad crossing. (From *Geology of Iowa.*)
‡ Water surface at Chicago and Northwestern railway crossing.
§ Water surface at mouth, by old survey.
‖ Chicago and Northwestern railway levels.
¶ Water surface, as above.

BOONE RIVER.

This river heads in Kossuth and Hancock counties, and flows southerly, joining the Des Moines from the east, 10 miles southeast of Fort Dodge; it is about 60 miles long by general course. Through Wright county its bed is composed of Drift material, but at Webster City it reaches the underlying rock, which is thereafter frequently exposed. The stream is comparatively small, but furnishes power to four flouring-mills, carrying two to four runs of stone each.

EAST FORK OF THE DES MOINES RIVER.

This stream has its extreme source in Jackson county, Minnesota, some 9 miles north of the Iowa boundary; its principal source, however, may be said to be in lake Okamanpadu, immediately south of that boundary. It flows southeasterly, and then southerly, joining the main river 11 miles north of Fort Dodge. Down to within a few miles of its mouth it is said to be, in general, a sluggish stream, with soft bed and banks, the latter quite low. At Algona it is 100 to 125 feet wide, and flows through a valley half a mile or a mile in width; its course is in the Drift formation, into which it does not cut its way sufficiently to expose the underlying limestone until it reaches the vicinity of Dakota. On either side of the valley rise low bluffs, beyond which is the open prairie. The latter is covered with soil of fair quality, not so rich as farther south, and is so slightly undulating as to appear level; it abounds in shallow basins, which are filled with water and choked with grass and weeds, and which usually have no visible outlet.

It is stated that lake Okamanpadu might be raised 4 feet by building a dam at its outlet. A mill privilege would thus be created a short distance below, with a head of 8 feet, and the flow of the stream would also be made more uniform. From the outlet of the lake down to Dakota the fall is reported to be so moderate, and the banks are said to be so low, that there are few opportunities for the further use of power. At Algona there is a four-run flouring-mill, using a head of 7½ feet; the dam consists of piles backed with loose stone, and rests upon a foundation of gravel, clay, and quicksand. At Dakota there is a three-run flouring-mill, with 7½ feet head. During freshets the river spreads out over the bottom-land, and the mills are hindered by backwater. As the ice moves down the river it is usually deposited on the flats, and causes no injury to the dams in this section; but farther down stream, where the banks are higher, it sometimes gives trouble.

Estimated volume and horse-power of tributaries of the Des Moines river.

Stream and locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
North Raccoon:	*Sq. miles.*						
At Grant City	724	40	45	60	68	100	114
At Northville	1,204	80	91	110	125	170	193
Above South Fork	2,001	150	170	190	216	280	318
Middle Raccoon above South Fork	502	30	34	60	68	80	91
South Raccoon:							
Above Middle Fork	389	20	23	40	45	50	57
Below junction	981	60	68	100	114	130	148
Above North Fork	1,141	80	91	110	125	160	182
Main Raccoon:							
Below junction North and South Forks	3,145	250	284	300	341	440	500
At mouth	3,629	270	307	310	352	470	534
Boone river:							
At Bach Grove	517	20	23	40	45	60	68
At mouth	899	50	57	70	80	100	114
East Fork Des Moines:							
At Algona	980	50	57	80	91	120	136
At mouth	1,357	70	80	110	125	170	193

Power utilized on the rivers of eastern Iowa.

[Below Dubuque, to and including Des Moines river.]

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Maquoketa	Mississippi	Iowa	Jackson	Flour and grist	1	12	48
Do	do	do	do	Flour, grist, and saw	2	14	90
Do	do	do	do	Saw	1	6	30
Do	do	do	Jones	Flour and grist	2	14	100
Do	do	do	Delaware	Flour, grist, and saw	1	11	65
Do	do	do	do	Flour and grist	5	56	255
Do	do	do	Buchanan	do	1	16	5
Do	do	do	Clayton	do	1	8	20
North Maquoketa	Maquoketa	do	Jackson	do	1	8	56
Do	do	do	do	Woolen	1	7	100
Do	do	do	Dubuque	Flour and grist	3	31	82
Do	do	do	do	Flour, grist, and saw	1	11	100
Do	do	do	do	Woolen	1	11	6
Small streams	do	do	Jackson	Flour and grist	5	54	192
Do	do	do	Jones	Flour, grist, and saw	1	12	40
Do	do	do	Delaware	Flour and grist	3	32½	40
Do	do	do	do	Saw	1	14	14
Do	do	do	do	Woolen	1	10	38
Do	North Maquoketa	do	Jackson	Flour and grist	3	31½	130
Do	do	do	do	Saw	1	7	25
Wapsipinicon	Mississippi	do	Clinton	Flour and grist	2	11	100
Do	do	do	Jones	do	3	19½	175
Do	do	do	Linn	do	2	14	88
Do	do	do	Buchanan	do	3	39	278
Do	do	do	Black Hawk	do	1	6	16
Do	do	do	Bremer	do	1	6	60
Do	do	do	Mitchell	do	1	9	27
Small streams	Wapsipinicon	do	Clinton	do	5	47	120
Do	do	do	Jones	do	1	7	55
Do	do	do	Linn	do	2	15½	53
Do	do	do	Buchanan	do	3	28	80
Do	do	do	Fayette	do	2	18	40
Iowa	Mississippi	do	Louisa	Flour, grist, and saw	1	9	85
Do	do	do	Johnson	Flour and grist	1	4	50
Do	do	do	Johnson (Coralville)	(See description)	3	9-11	696
Do	do	do	Iowa (Homestead)	do	6	8-12	335
Do	do	do	Iowa	Flour and grist	1	6	100
Do	do	do	Tama (Tama City.)	do	1	21	40
Do	do	do	do	Wind-mills	1		10
Do	do	do	do	Cooperage	1		8
Do	do	do	do	Agricultural implements	1		20
Do	do	do	do	Sash and blinds	1		10
Do	do	do	do	Paper	1		40
Do	do	do	Tama	Flour and grist	2	13½	110
Do	do	do	Marshall	do	3	18	176
Do	do	do	Hardin	do	9	72	545
Do	do	do	do	Woolen	1	10	50
Do	do	do	Wright	Flour and grist	1	7	12
Do	do	do	Hancock	do	1	9	20
English	Iowa	do	Washington	do	3	24	142
Do	do	do	Iowa	do	3	22	77
Deer creek	English	do	Johnson	Saw	1	5	14
Small streams	Iowa	do	do	Flour and grist	2	12	38
Do	do	do	Iowa	do	2	16	59
Do	do	do	Tama	do	4	35½	97
Cedar	do	do	Muscatine	do	1	4½	80
Do	do	do	Linn (Cedar Rapids)	do	4	6-8	315
Do	do	do	do	Foundery and machine	1		20
Do	do	do	do	Sash and blinds	1		80
Do	do	do	Linn	Flour and grist	2	21	30
Do	do	do	Black Hawk (Waterloo)	(See description)	5	5	402
Do	do	do	Black Hawk (Cedar Falls.)	do	9	8-9	491
Do	do	do	Black Hawk	Flour and grist	2	13	26
Do	do	do	Bremer	do	3	21	205
Do	do	do	do	Woolen	1	7	27
Do	do	do	Chickasaw	Saw	1	5	18
Do	do	do	do	Flour and grist	2	16½	110

Power utilized on the rivers of eastern Iowa—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Cedar	Iowa	Iowa	Floyd	Flour and grist	2	18	210
Do	do	do	Mitchell	do	7	51	458
Do	do	do	do	Flour, grist, and saw	1	7½	118
Do	do	do	do	Woolen	1	13	27
Do	do	Minnesota	Mower	Flour and grist	5	47½	269
Small streams	Cedar	Iowa	Cedar	do	6	102½	149
Do	do	do	Linn	do	7	94	163
Do	do	do	do	Woolen	1	17	5
Do	do	do	Benton	Flour and grist	2	35	55
Do	do	do	Tama	do	2	17	85
Do	do	do	Buchanan	Cheese and butter	1	3	6
Do	do	do	Black Hawk	Flour and grist	2	16	55
Do	do	do	do	Cheese and butter	1	4	1
Do	do	do	Franklin	Flour and grist	1	30	55
Do	do	do	Chickasaw	do	1	10	38
Do	do	do	Mitchell	do	2	16½	56
Do	do	Minnesota	Freeborn	do	1	9	40
Do	do	do	Mower	do	1	16	30
Shell Rock	do	Iowa	Butler	do	5	33	259
Do	do	do	Floyd	do	4	35	282
Do	do	do	Cerro Gordo	do	2	28	115
Do	do	do	Worth	do	2	16	130
Do	do	do	do	Woolen	1	8	10
Do	do	Minnesota	Freeborn	Flour and grist	1	5½	15
Small streams	Shell Rock	Iowa	Black Hawk	do	1	6½	40
Do	do	do	Butler	do	3	26	88
Do	do	Minnesota	Freeborn	do	1	18	40
Lime	do	Iowa	Floyd	do	1	10	75
Do	do	do	Cerro Gordo	do	5	43	222
Willow	Lime	do	do	do	1	11	50
Skunk	Mississippi	do	Lee	do	1	6½	25
Do	do	do	Des Moines	do	1	7	45
Do	do	do	Henry	do	5	31	282
Do	do	do	Jefferson	do	1	7	70
Do	do	do	Washington	do	1	6	50
Do	do	do	do	Flour, grist, and saw	1	9	55
Do	do	do	Keokuk	do	1	8	50
Do	do	do	do	Flour and grist	2	22	135
Do	do	do	Mahaska	do	4	24	113
Do	do	do	Story	do	1	8	100
Small streams	Skunk	do	Henry	Saw	1	7	15
Do	do	do	Jefferson	Flour and grist	1	9	18
Do	do	do	Jasper	do	2	16	42
North Skunk	do	do	Keokuk	do	1	10	20
Do	do	do	Mahaska	do	6	48½	240
Do	do	do	Poweshiek	do	2	17	70
Des Moines	Mississippi	Missouri	Clarke	do	1	8	20
Do	do	Iowa	Van Buren (Bonaparte)	(See description)	3	8	100
Do	do	do	Van Buren (Bentonsport)	do	4	7	151
Do	do	do	Wapello (Ottumwa)	do	7	8½	275
Do	do	do	Marion	Flour and grist	1	5	75
Do	do	do	Polk	do	1	5	120
Do	do	do	Humboldt	do	3	38	217
Do	do	do	Palo Alto	do	1	8	80
Do	do	Minnesota	Jackson	do	3	25½	208
Do	do	do	Cottonwood	do	1	10	70
Do	do	do	Murray	do	1	8	51
Middle river	Des Moines	Iowa	Warren	do	1	7½	50
Do	do	do	do	Flour, grist, and saw	1	6	38
Do	do	do	Madison	Flour and grist	3	34	78
Do	do	do	Adair	do	3	35½	41
Raccoon	do	do	Polk	do	2	9	60
Do	do	do	Dallas	do	2	11½	75
North Raccoon	Raccoon	do	do	do	2	19	100
Do	do	do	Greene	do	5	38	108
Do	do	do	Carroll	do	1	7	20
Do	do	do	Calhoun	do	1	10	18
Do	do	do	Sac	do	2	19	62

Power utilized on the rivers of eastern Iowa—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Middle Raccoon	South Raccoon	Iowa	Dallas	Flour and grist	1	11	30
Do	do	do	do	Flour, grist, and saw	1	7	40
Do	do	do	Guthrie	Flour and grist	3	27	102
Do	do	do	do	Saw	1	6	25
South Raccoon	Raccoon	do	Dallas	Flour and grist	3	20½	112
Do	do	do	do	Flour, grist, and saw	1	6	100
Do	do	do	Guthrie	Woolen	1	6½	24
Do	do	do	do	Flour and grist	4	30	140
Boone	Des Moines	do	Hamilton	do	6	43½	170
East Fork Des Moines	do	do	Humboldt	do	1	7½	(?) 45
Do	do	do	Kossuth	do	1	7½	57
Small streams	Mississippi	do	Dubuque (below Dubuque city).	do	3	60	71
Do	do	do	Jackson	do	8	117	324
Do	do	do	Clinton	do	7	112	164
Do	do	do	do	Flour, grist, and saw	1	12	60
Do	do	do	Muscatine	Flour and grist	1	20	70
Mississippi		do	Scott	do	2		*110
FIRST SUMMARY.							
Maquoketa	Mississippi	do			14	137	613
North Maquoketa	Maquoketa	do			7	68	344
Small streams	Maquoketa and North Maquoketa.	do			15	161	497
Wapsipinicon	Mississippi	do			13	94½	744
Small streams	Wapsipinicon	do			13	115½	348
Iowa	Mississippi	Iowa			35	102½	2,307
Cedar	Iowa	Iowa and Minnesota.			48	247	2,886
Shell Rock	Cedar	do			15	125½	811
Small streams	Iowa	Iowa			15	114½	427
Do	Cedar and tributaries	Iowa and Minnesota.			40	400½	1,253
Skunk	Mississippi	Iowa			18	128½	925
North Skunk	Skunk	do			9	75½	345
Small streams	do	do			4	32	75
Des Moines	Mississippi	Iowa and Minnesota.			26	131	1,427
Middle	Des Moines	Iowa			8	83	207
Raccoon	do	do			4	29½	135
North Raccoon	Raccoon	do			11	93	308
Middle Raccoon	South Raccoon	do			6	51	107
South Raccoon	Raccoon	do			9	72	301
Boone	Des Moines	do			6	43½	170
East Fork Des Moines	do	do			2	15	102
SECOND SUMMARY.							
Maquoketa and all tributaries.	Mississippi	do			36	366	1,454
Wapsipinicon and all tributaries.	do.	do			26	210	1,092
Iowa and all tributaries	do	Iowa and Minnesota.			153	1,170	7,684
Skunk and all tributaries	do	Iowa			31	236	1,345
Des Moines and all tributaries.	do	Iowa and Minnesota.			72	509	3,036
Sundry small streams	do	Iowa			20	321	680
Mississippi		do			2		110
Total eastern slope of Iowa, below Dubuque.					340	2,812	15,410

*Current-wheels.

VII.—THE EASTERN MISSOURI SLOPE.

For convenience I include in this division those rivers, other than the Missouri, which flow into the Mississippi from the west, below the Des Moines, down to, and including, the Saint Francis; the latter has much of its course within Arkansas, but the upper waters, the only portion having any available power, lie in Missouri. Between Des Moines and the Missouri rivers are encountered, successively, the following streams: Fox river, drainage area, 450 square miles; Wyaconda river, 452 square miles; Fabius river, 1,523 square miles; North river, 468 square miles; Salt river, 2,956 square miles; and Cuivre river, 1,088 square miles. It may be said, in brief, regarding these streams, that they have practically no value for power. They are very sluggish, and are thought to have a fall in the main portions of their courses but slightly greater than that of the Mississippi, which sets up into them for 2 or 3 miles above their mouths. They drain a rather rough country, well wooded, but entirely deficient in springs; being forced, therefore, to depend upon surface drainage, they are characterized by great unevenness of flow; during summer they run very low, and some, such as the Fabius, are said to become dry; on the other hand, after heavy rains they rise quickly, overflow their banks, and submerge their valleys far and wide. Salt river is the largest of these streams, but probably would not itself furnish power, in low water, for more than a moderate-sized grist-mill. It runs through a valley half a mile to a mile wide, its own width between banks being about 300 feet. These are 12 to 15 feet high above low water, but during freshets the river rises 4 to 8 feet above them.

THE MERAMEC RIVER.

This is the first important stream south of the Missouri. It rises in Phelps and Dent counties, pursuing thence a northeasterly course to the Mississippi, which it reaches about 20 miles to the south of Saint Louis. It drains an area of 3,914 square miles, the surface of which is rough and broken, thickly timbered, and with a rather shallow covering of soil. The river runs through a valley ranging from a quarter of a mile in width, in the upper course, to three-quarters of a mile toward the mouth. Limestone cliffs frequently rise abruptly from the water, while on the opposite side of the stream is a level bottom subject to overflow in high water. The bed is usually of gravel, though rock ledges and bowlders occasionally appear. The upper river is described as a chain of rapids, and these continue, at longer intervals, down stream; none of them, however, are of great pitch, the largest fall at any point below Phelps county being 6 feet in 950 yards, 15 miles from the Meramec iron-works. The banks vary considerably in height, but, exclusive of the bluffs, average 10 to 12 feet above low water; where succeeded by bottom-land, they are composed of alluvial soil underlaid by gravel.

Elevations and slope of the Meramec river.

Locality.	Elevation above sea.	Fall between points.*	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile*
Head spring	755½	140	38¼	3.66
Mouth of Courtois	615½	157	49¾	3.16
Mouth of Bourbeuse	458½	51½	28	1.84
Mouth of Big river	407	42	56½	0.74
Mouth of Meramec†	365			

* From report by William H. Morell, chief engineer, to the Missouri legislature, in 1840.
† Low water in Mississippi river, by levels of precision under Mississippi River Commission.

The Meramec is not a navigable stream. It was examined in 1880, under the direction of Captain O. H. Ernst, corps of engineers, but the expense of rendering it navigable was found so large, in comparison with the commerce of the valley, as to forbid such improvement. The Saint Louis and San Francisco railroad follows the greater part of the course of the river, nowhere distant more than 7 or 8 miles from it (except toward the mouth), and the Missouri Pacific road also runs along the lower valley for some distance.

The width of the river increases from about 150 feet in its upper course to 200 feet in the middle course, and 300 or 400 feet near the mouth. The steep rocky slopes of the country drained quickly shed into the stream the water of heavy rains, and sudden, rapid rises occur. The range between high and low water is 8 to 12 feet in the upper waters, and 17 to 20 feet in the middle and lower portions. The principal rise is in the spring.

The use of the Meramec for power is confined to a few small flouring- and grist-mills of one or two runs each. Only one of these was visited by me—that located in Phelps county near a remarkable spring which is the source of one of the upper forks. This spring is at the foot of a hill, and discharges into a pool of half an acre to an acre in

extent, formed by a rude dam of stones. A race some 400 feet long starts from the pool, and conveys water to a small flouring-mill using 12 feet head and 20 horse-power. The flow from this spring is estimated at 100 to 150 cubic feet per second, and is very uniform, though greater in spring than in summer. The stream issuing from it I observed to be 50 to 75 feet wide, 3 or 4 feet deep, and running with rapid current. At the distance of half a mile it unites with the East Fork. The Meramec iron-works, immediately below the spring, formerly used its waters for power to run a blast-furnace and forge, employing a head of 12 feet and several water-wheels, rated in the aggregate at 300 horse-power. These works were quite extensive, but are not now in operation.

The Meramec has sufficient volume to supply powers of considerable size, the chief disadvantages to its use being the sudden and rather heavy freshet rises, and the difficulty of finding high firm banks simultaneously on both sides. The discharge of the stream at its mouth, as estimated by Mr. Max E. Schmidt, who conducted the government reconnaissance in 1880, is about 600 cubic feet per second in extremely low water, or 0.15 cubic foot per second per square mile of drainage area. The average rainfall on the basin is 11½ inches in spring, 12 in summer, 8 in autumn, 7 in winter, and 38½ for the year. I estimate the volume and horse-power at different points on the river as follows:

Estimated volume and horse-power of the Meramec river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Below Courtois	1,325	210	230	290	329	390	443
Southern edge Franklin county	1,529	230	261	330	375	440	500
Below Bourbeuse	2,080	400	454	500	568	690	784
Mouth of river	3,014	580	659	700	795	970	1,102

Below the junction of what are known as the Dry Fork and Water Fork, the principal tributaries of the Meramec are the Courtois, drainage area 450 square miles; Bourbeuse, 831 square miles, and Big river, 919 square miles. The Bourbeuse and Big rivers discharge 70 to 100 cubic feet per second in a low stage, and the latter with its tributaries furnish power to quite a number of flouring- and grist-mills, all, however, of small size and averaging not over 20 horse-power each.

Table of power utilized on the Meramec river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Meramec	Mississippi	Missouri	Franklin	Flour and grist	1	17½	10
Do	do	do	Crawford	do	2	23	23
Do	do	do	Dent	do	1	12	16
Big	Meramec	do	Jefferson	do	3	19	74
Do	do	do	Saint François	do	2	13	35
Small streams	Big	do	do	do	1	24	12
Do	do	do	Washington	do	11	190	210
Do	Meramec	do	Franklin	do	2	13	32
Do	do	do	Washington	Saw	1	33	15
Do	do	do	Crawford	Flour and grist	6	70	70
Do	do	do	Phelps	do	1	12	20
Total					31	435½	517

THE SAINT FRANCIS RIVER.

This river, the only important one joining the Mississippi from the west between the Meramec and the Arkansas, has its sources in Saint François and Iron counties, in southeastern Missouri; it runs southerly into Arkansas, its course throughout being approximately parallel to that of the Mississippi, and empties a short distance above Helena. Its water-shed lines are not easily traced, but embrace an area of at least 8,000 square miles. This section presents two marked varieties of surface. The upper waters of the river drain an elevated region constituting a slope of the Ozark mountains, which strike easterly through southern Missouri. This slope falls away quite rapidly toward the south and east, and is the only portion of the Saint Francis basin possessing water-power of any value; it has

valuable resources, and abounds in iron, copper, and lead; deposits of zinc and other minerals are also found. At the headwaters are Pilot Knob and Iron mountain, almost solid masses of iron ore of the greatest purity. Granite and porphyry hills rise in some cases 600 or 700 feet above the river, and in various localities there are quarries of granite, sandstone, and limestone, suitable for building purposes. This upper basin is well timbered with a young growth, comprising oak, ash, hickory, walnut, poplar, beech, and pine; the soil is fertile, and yields good crops of corn, wheat, oats, and rye.

South of this elevated portion of its basin the Saint Francis enters upon a low, partially sunken region, extending from the southern boundaries of Wayne, Bollinger, and Cape Girardeau counties, Missouri, 200 miles farther south to the mouth of the river. The country thus drained is covered with a net-work of bayous and swamps, and the expansions of the streams and bayous into lakes. Probably the surface was naturally somewhat rolling, and there are now numerous ridges, usually extending in a north-and-south direction, which are entirely above overflow; but in the great earthquake of 1811 a large part of the district in the vicinity of New Madrid sank below its former level, and is now frequently submerged. These lowlands are thickly overgrown with cypress, oak, elm, ash, hickory, and willow; the soil is rich, and where above overflow produces well in corn, wheat, rye, oats, and cotton. In northeastern Arkansas the river widens into a lake some 70 miles long, and in places several miles wide.

Slope of the Saint Francis river. (a)

Locality.	Elevation above sea.	Fall between points.	Distance between points.	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Headwaters*.....	1,150			
Ironton†.....	887	836	190	0.43
East boundary Butler county, Missouri.†	314	153	173	0.88
Wittsburg, Arkansas‡.....	161			
Mouth of river	144	17	135	0.13

* Elevation as given by Humphreys and Abbot.
† Low water at crossing of Saint Louis, Iron Mountain and Southern railway.
‡ Low water in Mississippi, by levels of precision under Mississippi River Commission.

NOTE.—The distances between points are by map measurement above Wittsburg; but the distance and fall from Wittsburg to the mouth are from the report of an examination by Mr. H. L. Koons. (See *Report Chief of Engineers*, 1871, p. 358.)

The Saint Francis is navigable for light-draught steamers, eight months in the year, to Wittsburg, but above that point its course is much obstructed by bars, snags, and overhanging trees. There are no large towns on the lower river, and the upper basin is also sparsely settled; Pilot Knob and Ironton, near the source, contain populations of about 1,400 and 800, respectively.

The upper river has a rocky bed and a quite rapid descent. At the crossing of the Iron Mountain road, on the eastern border of Butler county, there is a difference of 17 feet between high and low water, but the oscillation is probably much less farther up stream, though I do not know its amount. (*b*) This part of the river is rather inaccessible, and is only to be reached by the Saint Louis, Iron Mountain and Southern railway, which, except in the extreme upper waters, is distant 10 or 12 miles from its course. There is scarcely any use of water-power on the main river, but an occasional small mill is to be found on the little tributary creeks in Wayne, Madison, and Bollinger counties. In Madison county there is a single flouring-mill on the Saint Francis with 10 feet head and 59 horse-power, and a few miles west of Fredericktown the Silver Mountain Mining Company use 80 horse-power from the stream. They obtain a fall of 22 feet over a granite and cement dam; this structure is 24 feet wide at the base, battering to 6 feet at the top; the length of over-fall is 163 feet, and the length at base 95 feet. The breast of the dam is faced with a mass of riprap 6 feet wide at the foot and gradually thinning out toward the top.

Before reaching the region of the lowlands the river now and then cuts through rocky hills, in narrow gorges well suited to its control for power. One of these gorges occurs in Madison county, near the Einstein silver mine, and is thus described by Mr. William Einstein:

> The Saint Francis river, in its course through the northeastern part of township 33, range 5 east, cuts through granite and porphyry hills, the elevations above the river bed on either side being from 200 to about 400 feet. The bed of the river is solid rock, conforming to the hills on either side; the channel is from 100 to 150 feet in width, with an amount of water in the dryest season of the year sufficient for a very respectable power, limited only by the greater or less height of the dam. The flow of the river is steady, and in an ordinary stage will give, with 10 feet head, an important power at least ten months in the year.

Mr. Einstein further says:

> Rocky chasms, similar to the above, occur at various other places on the river, but, to my knowledge, none so favorably located. I consider these features as being very favorable for the development of power if the site selected is easy of access. Occasional floods occur, but nothing to interfere with properly-constructed works.

a This stream is 250 miles long by general course, but its actual length is probably at least twice as great.
b At Ironton the rise in Stout's creek is about 4 feet.

For a considerable distance into Wayne county the river continues rapid, with a width of 175 feet at ordinary stage, and is said to have value for power; at several points it cuts through solid ledges of rock, and occasional side channels, or sloughs, are to be found, of which advantage might be taken. Upon approaching the swamp-lands in the southern part of this county the stream becomes entirely unsuited to use, and is subject to quite heavy oscillations, which increase in the lower course to from 30 to 50 feet.

Toward its mouth the river is joined from the west by the L'Anguille, a sluggish stream flowing through swamps and lowlands. In the upper basin the principal tributaries are the Castor and Little rivers. The former and the Whitewater, a branch of Little river, furnish power to a few small mills, but they drain only limited areas before entering the lowlands.

The rainfall on the upper basins of the Saint Francis, Castor, and Whitewater, is approximately 10½ inches in spring, 10 in summer, 10 in autumn, and 9 in winter, giving 39½ inches for the year. From the even distribution of the rainfall among the seasons it is to be expected that the streams run comparatively low in summer and autumn. There being no recorded measurements of their volume, I estimate their discharge and the corresponding horse-power as below:

Estimated volume and horse-power of the upper Saint Francis river and tributaries.

Stream and locality.	Drainage area.	Available 10 months in average year.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.		
Saint Francis, due west of Fredericktown, and above the Little Saint Francis.	384	90	102
Saint Francis, at southern line of Madison county	731	170	193
Saint Francis, at Greenville	1,027	240	273
Castor, at Buchanan	274	60	68
Whitewater, at Strodersville	353	80	91

Power utilized on the Saint Francis river and tributaries, with a summary for the eastern Missouri slope.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Saint Francis	Mississippi	Missouri	Madison	Flour and grist	1	10	59
Do	do	do	do	(Silver mine)	1	22	80
Sundry streams	Saint Francis	do	Stoddard	Flour and grist	1	7	20
Do	do	do	do	Saw	1	10	30
Do	do	do	Wayne	Flour and grist	4	34	68
Do	do	do	do	Flour, grist, and saw	2	26	43
Do	do	do	do	Woolen	1	5	6
Do	do	do	do	Saw	1	6	12
Do	do	do	Bollinger	Woolen	1	14	5
Do	do	do	do	Flour and grist	5	42	51
Do	do	do	Madison	do	4	36	69
Do	do	do	Iron	Woolen	1	6	8
Do	do	do	Cape Girardeau	Flour and grist	3	27	78
Do	do	do	do	Flour, grist, and saw	3	24	110
Total					29	269	639
SUMMARY.							
Meramec and tributaries	Mississippi	do			31	435½	517
Saint Francis and tributaries	do	do			29	269	639
Small streams	do	do	Shelby	Flour and grist	1	9	30
Do	do	do	Monroe	do	2	11½	44
Do	do	do	Lincoln	do	1	8	44
Do	do	do	Jefferson	do	2	40	31
Do	do	do	Saint Genevieve	do	2	20	27
Do	do	do	Perry	do	2	18	52
Do	do	do	do	Flour, grist, and saw	1	10	46
Do	do	do	do	Saw	1	11	16
Do	do	do	Saint François	Flour and grist	1	20	20
Total					73	852	1,466

VIII.—THE ARKANSAS RIVER BASIN.

The region included within the water-shed of the Arkansas river lies between the Mississippi river and the Rocky mountains, and though it stretches a long way east and west, may be said to be located, as a whole, a little south of the center of the United States. It extends from the meridian of 91° to midway between the meridians of 106° and 107°. At the source of the Arkansas river it touches latitude 39° 22′ north, while near the mouth its southern limit is latitude 33° 49′. The tract of country thus embraced has an area of about 188,000 square miles, (*a*) and is distributed among different states as follows:

	Square miles.
Colorado	28,100
New Mexico	16,900
Kansas	41,800
Indian territory	45,400
Texas	12,600
Missouri	13,700
Arkansas	29,600
Total	188,100

These areas must be regarded as only approximately correct, for the water-shed lines cannot be laid down with a certainty of their being accurate upon existing maps.

CHARACTER OF THE SURFACE.

The vast area of the Arkansas River basin presents great diversity in topography and resources. At its western boundary are the high ranges of the Rocky mountains, shutting it off from the basin of the Colorado river. In those mountains the passes range from 8,000 to 10,000 feet in elevation above sea-level, while some of the peaks tower up to heights of 14,000 feet and upward. Mount Lincoln stands directly at the source of the Arkansas river, and is more than 14,000 feet high. From this point the water-shed line extends southward along the ridge of the Sawatch mountains and Sangre de Cristo range into New Mexico; it is then continued still farther, around the headwaters of the Canadian river, by the Taos and Las Vegas ranges.

West of longitude 105° the country may be described in general as mountainous, heavily timbered, mainly with pine, and abounding in minerals, the mining of which constitutes the chief industry. Here are found extensive deposits of silver, gold, copper, lead, and coal. Notwithstanding that the mountains seem almost impassable, railroads have been built up the valleys of the streams, and the more prominent mining towns, such as Leadville, Rosita, Silver Cliff, and many others, have been rendered easily accessible.

East of the mountainous section we enter quite abruptly upon the seemingly endless rolling prairies, which stretch on to Missouri and Arkansas. For 500 to 600 miles from the mountains the country presents substantially the same general contour; there is, on the whole, an imperceptible and gradually decreasing slope away from the mountains, averaging for the whole distance not far from 8 feet to the mile. In the immediate vicinity of the mountains the natural fertility of the soil, the rapid descent and, at certain seasons, considerable volume of the streams, combine to render irrigation successful, and the soil is made to yield fine crops of wheat and other grains. Farther east, however, the soil is sandy, irrigation is less practicable, and we find a region without timber and unsuited to agriculture.

Approaching the meridian of 98° the character of the country greatly improves; timber is found to a moderate extent, the rainfall is greater, the soil is productive, and, as a rule, returns large crops of the various grains. South of the Great Bend, near the southern line of Kansas, are found large deposits of crystallized salt, in beds 6 to 28 inches thick, supposed to have resulted from the drying up of salt ponds or salt branches of the Cimarron river.

A very large portion of the Indian territory is embraced within the Arkansas basin. Corn is its main production, though wheat is also raised. It is said that cotton was formerly largely cultivated south of the Canadian and along the Arkansas and Red rivers, and some attention is still paid to it. West of the meridian of 97° a narrow belt of timber, called the Cross Timbers, stretches from the Cimarron southwesterly into Texas. West of this belt, and north of the Canadian Fork, the country is barren and unproductive, covered in places with salt and alkaline deposits. The northeastern part of the Indian territory is well timbered with cottonwood, oak, sycamore, elm, walnut, ash, and yellow pine. Considerable portions of its surface are fertile, but it contains also much poor and rocky land. Underlying it are found iron, brick-clay, and some good building stone; a valuable bed of bituminous coal extends from this section of the territory in a northeasterly direction through Missouri, passing across the adjacent corners of Kansas and Arkansas.

a Including White River basin.

Nearing the eastern border of the Indian territory we encounter a rough, mountainous section, which continues into Arkansas and Missouri. Crossing the Arkansas river near Fort Gibson, the low ranges of the Ozark mountains strike northeasterly across the corner of Arkansas, and passing through southern Missouri constitute the water-shed between the Missouri and White rivers. (*a*) These mountains abound throughout their extent in iron, lead, zinc, and other minerals, and thus contribute valuable resources to the section in which they lie. A spur, known as the Boston mountains, runs easterly into Arkansas for a considerable distance, and forms the more immediate northern water-shed of the Arkansas river. To the south of that river is the Washita range, said to be so barren in appearance that the gray sandstone of which it is composed gives the prevailing color to the landscape.

Extending from the western border of the state to Little Rock are the coal-fields of Arkansas; they lie on both sides of the Arkansas river, and embrace the greater portions of all the counties touching upon the stream in the distance mentioned. The coal is of a semi-bituminous variety and has been principally mined from the strata of the Upper Coal Measures; it occurs in veins 3 to 9 feet thick, and frequently lies less than 20 feet below the surface. In the central part of Arkansas the surface is less rough, and is largely a rolling prairie, with more or less timber interspersed. Toward the mouth of the river the country is low and heavily timbered. It has a rich, black alluvial soil, and where cultivated yields largely in cotton and corn.

The population of the Arkansas basin exhibits an important increase for the decade ending in 1880, having more than doubled.

Population of the Arkansas River basin.

[From Mr. Gannett's statistics.]

Drainage basin.	Approximate area.	Population, 1870.	Population per square mile in 1870.	Population, 1880.	Population per square mile in 1880.
	Sq. miles.				
Arkansas river	185,071	613,672	3.3	1,273,853	6.8
Cimarron river	16,632	427	.....	1,392	0.1
Canadian river	41,052	17,081	0.4	22,552	0.5
White river	20,550	201,030	9.1	461,309	15.6

The great bulk of settlement is confined to three sections along the river: The valley of the main stream and White river, in Arkansas, and southern Missouri; southern and southeastern Kansas, and the country lying toward the foot of and among the Rocky mountains.

CLIMATE.

The climate of the region which I am describing is in the main extremely healthy. The low valleys along the lower Arkansas and White rivers, like similar districts elsewhere, are visited by fevers and malarial diseases; but even there the higher lands are regarded as favorable to health, and farther westward are the elevated prairies, the value of whose dry, bracing air is everywhere known.

The winds vary considerably with location and season, but the prevailing winds of the year may be taken as lying between west and southwest, in southeastern Colorado, while for the remainder of the basin they range from southwest to southeast.

There are few long-continued records of temperature and rainfall for points in the Arkansas basin, but the ones given below, which are copied from the Smithsonian tables, will give a very good idea of those phenomena in different sections:

Locality.	Elevation.	Latitude.	Longitude.	Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
TEMPERATURE.	*Feet.*	° ′	° ′		°*F.*	°*F.*	°*F.*	°*F.*	°*F.*
Fort Union, New Mexico	6,070	35 54	104 57	17	49.58	67.94	51.49	33.50	50.63
Fort Garland, Colorado	8,365	37 32	105 40	15	42.03	64.39	43.49	20.63	42.86
Dodge City, Kansas	2,490	37 30	100 00	*9	54.11	76.42	54.10	32.30	54.23
Fort Gibson, Indian territory	500	35 48	95 20	30	61.08	79.13	61.44	40.25	60.48
Fort Smith, Arkansas	460	35 23	94 20	19	60.70	78.48	60.65	40.55	60.12
RAINFALL.					*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Fort Union, New Mexico	6,070	35 54	104 57	17	2.12	11.92	3.73	1.32	19.09
Fort Garland, Colorado	8,365	37 32	105 40	13	3.28	6.70	2.37	2.51	14.86
Fort Larned, Kansas	1,932	38 10	98 57	11	5.17	9.03	4.95	1.07	21.42
Fort Gibson, Indian territory	560	35 48	95 20	24	11.44	9.65	9.30	6.57	36.96
Fort Smith, Arkansas	460	35 23	94 20	23	11.07	11.07	9.87	7.60	40.51

* Combined with signal-service observations.

a I am informed by Mr. James Dun, chief engineer of the Saint Louis and San Francisco railway, that in northwestern Arkansas, near the headwaters of White river, the Ozark mountains have an average elevation of about 2,200 feet above tide.

GENERAL FEATURES OF THE STREAMS.

My work in connection with the Arkansas was confined to short visits to some of the more prominent towns on the main river and its tributaries in southeastern Kansas, and to the vicinity of the headwaters of White and Black rivers in Arkansas and Missouri. My information upon other and remote portions of the basin has been derived from various sources, mainly from Humphreys and Abbot's report, and more recent reports by other government engineers of surveys and examinations of the different streams, made with a view to their improvement for navigation. (a)

The characteristics of some of the more important streams will be given in detail further on, but there are certain features possessed by them in common, and due to circumstances of topography, soil, and climate, which may properly come into this general description. In the upper basin of the Arkansas there are numerous streams, principally short ones, which either lie wholly in, or at least have their sources among, the mountains. In their general character as mountain streams they probably do not differ essentially from the upper tributaries of the Platte, which have been described in connection with that river, and doubtless might be used to good advantage for power in many cases if there were any demand for such use. Those which head in the mountains and find their way out into the prairies are used more or less for irrigation. The rainfall and temperature of the section drained by these mountain streams are calculated to cause large variations in their volume during different seasons of the year. The average winter temperature at Fort Garland, Colorado, is 11 degrees below freezing point, and is less than 2 degrees above freezing point at Fort Union, New Mexico, so that a large share of the precipitation of winter in the adjoining regions must be, and remain during that season, in the form of snow. At the same time the amount of winter precipitation is very small compared with that of summer. Thus at Fort Union more rain falls during the summer than in all the rest of the year, and far the greater part of the summer rain is in the two months of July and August. At Fort Garland there is a similar disproportion, though not quite so marked. It is evident, then, that the streams will run lowest in fall and winter. In spring the melting snow will swell their volumes, and during the heavy rains of summer, quickly shed from the steep slopes of the mountains, they are likely to reach their highest pitch.

Passing eastward from the mountains the rivers encountered, as far as the borders of Missouri and Arkansas, are distinctively prairie streams; they rise in the prairies, and their courses lie entirely in them. They are bordered by bottom-lands ranging from half a mile to several miles in width; in eastern Colorado and western Kansas the bottoms are rather light and sandy, but farther east are alluvial in nature. On either side there rise rounded bluffs, 50 to 300 feet high, and beyond these is the open, rolling country, the valleys of the streams being depressed below its general level. The river beds are sandy or muddy, and to a large extent are composed of quicksand. There are no abrupt falls, and the streams run smoothly, with quite uniform descent, their prevailing slope decreasing as they recede from the mountains.

The absence of rock ledges upon which to found dams is, of course, very unfavorable to the improvement of these streams for power; but it need not debar such improvement, for where crib-work or framed dams have been found impracticable on such rivers, those constructed of brush have usually met with good success. They suffer another great disadvantage, however, arising from their large variations in volume. Many of them, especially to the west of the Great Bend in Kansas, run dry every year, while others, such as the Neosho, and even the Arkansas itself, have shown the same phenomenon at intervals. These fluctuations in the streams are due, partly to the surface features of the country, and partly to peculiarities of climate. The effect which the nature of the surface has upon their steadiness may be judged from the following extract from a report by Mr. William Tweeddale, civil engineer, to the Hutchinson (Kansas) Water-Power Company; speaking of the Arkansas river, he says:

> The water-shed on either side is rolling prairie, the soil of which is mostly clayey loam intermixed with sand. For ages destitute of trees, the soil in Colorado and western Kansas, under the combined influence of rains tropical in character, high winds, and scorching southern sun, has become so compact that herbage is scant. The surface, thus unprotected, has become baked so as to be nearly impervious to water, for which reason rains do not infiltrate into the soil and form springs, but are carried at once into the water-courses. From 50 miles west of Hutchinson to the south line of the state the country is comparatively level, and the soil sandy, for which reason springs are more abundant, and the flow of the streams is plentiful and uniform.

The same unequal distribution of rainfall among the different seasons which has been noticed toward the headwaters of the Arkansas continues eastward through Kansas. Thus at Fort Larned we find the average winter rainfall to be 1.67 inches, and the summer rainfall 9.63 inches; at Fort Scott, near the eastern border of the state, the precipitation is in winter 4.79 inches, and in summer 16.37 inches. With such a comparatively heavy rainfall in the warm season, principally concentrated in the late spring and early summer, and occurring largely in the form of violent showers, which fall upon the hardened surface of the ground, nothing less could be expected than that there should be great fluctuations in the volumes of the streams. Nor is it surprising that in the late summer and autumn, when the rainfall has greatly diminished, and evaporation is still large, they should in many cases sink away in their sandy beds and disappear from sight. Over all the upper Arkansas basin the evaporation must be great; the prevailing winds are west to southwest, and, having been stripped of their moisture beyond the mountains, seek to replenish their store from the country to the east.

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a From Captain Thomas H. Handbury, corps of engineers, I received much information regarding the lower Arkansas river. Many railroads supplied lists of elevations on their lines, and to Mr. H. V. Hinckley, assistant engineer of the Atchison, Topeka and Santa Fé railroad, I am especially indebted for the altitudes of a large number of points on the main and branch lines of that company.

Southeastern Kansas is the portion of the Arkansas basin in which there is the most use of water-power, though it is quite limited even there. In recent years there has been a large emigration to that section, resulting in a much increased cultivation of the soil; new railroads have been constructed, giving good facilities for transportation, and many flouring-mills have been built, which have availed themselves of the natural power afforded by the rivers and minor streams. Very many available sites still remain undeveloped, though I am unable to mention them in detail, as might be practicable with rivers of a different nature. These prairie streams preserve essentially the same features throughout, and, generally speaking, if they have any value for power, they can be improved at short intervals all along their courses, certain local advantages determining the selection of one point or another. When possible, the total fall in different sections of the streams will be given; the power utilized in the successive counties will appear in a subsequent table; and by comparison of these two sets of data some idea may be formed of the extent to which the streams will still admit of improvement.

Passing eastward into Arkansas and Missouri we encounter, successively, mountain and prairie streams, and, approaching the Mississippi, sluggish rivers and bayous entirely valueless for water-power. The streams of the first two classes would, no doubt, furnish many good powers of moderate size, though they are unreliable in flow. The section in which they lie is sparsely settled, and very deficient in railroad facilities; naturally there is but little demand for power, and they are scarcely at all utilized.

An increase of storage capacity beyond that afforded by the mill-ponds along the streams is, in general, impracticable in the Arkansas basin. There are no lakes or ponds, worth mentioning, to be raised by dams, and though, in the mountainous section near the headwaters, and again in Arkansas and southern Missouri, dams might be thrown across favorable ravines and a limited amount of storage developed, yet in the open prairies there are few such opportunities. The side streams are small; it is difficult to find suitable foundations for high and strong dams; and if the reservoirs were permitted to spread much beyond the natural banks heavy damages might be incurred from the submergence of rich bottom-lands.

IX.—THE ARKANSAS RIVER.

The Arkansas river has its source in the central part of the state of Colorado, in latitude 39° 22′, and longitude 106° 12′. Its course is in the main southeasterly, and passes successively through southeastern Colorado, portions of Kansas and the Indian territory, and the state of Arkansas. In Desha county of the latter state it empties into the Mississippi, about 700 miles above the mouth of that river. It measures 1,100 miles along its general course from source to mouth, but its actual length is much greater. The old mouth of the river was at Napoleon, and at high stages more or less water is still discharged at that point through its former channel; but ordinarily its main volume flows through a bayou or cut-off, several miles above, into White river, and so in a manner reduces that stream from the position of an independent river to that of a tributary of the Arkansas. Inclusive of White river, the Arkansas drains an area of about 188,000 square miles, or, without that stream, about 160,000 square miles.

For its first 120 miles the river is a mountain torrent, flowing over a rocky bed, with clear waters and rapid descent. Above Cleora the area drained varies from 10 to 35 miles in width, and is hemmed in by mountains, down the sides of which tumble numerous little streams making their way to the main river. The elevation of the latter is reduced from about 10,000 feet at the head to less than 5,400 at Cañon City; in other words, the river loses nearly one-half its elevation in 120 miles from the source. The Denver and Rio Grande narrow-gauge railroad follows closely this portion of the river to the headwaters.

In the vicinity of Cañon City the Arkansas makes its escape from the mountains, after passing through a magnificent gorge, or cañon, in which it descends more than 300 feet. From Cañon City to Pueblo, a distance of about 41 miles, the average descent is not far from 16 feet to the mile. For the greater part of this distance the river averages 175 feet in width, and is 3 to 5 feet deep. Pueblo is the most important city in this section, and has a population of about 3,200. From Pueblo to the eastern boundary of Colorado, the principal tributaries of the Arkansas are, in order, from the north, Fountain qui Bouille, Chico, Horse, and Big Sandy creeks; and from the south, Huerfano river, Purgatoire river, and Two Butte creek. The general course of the stream is, in this distance, easterly, running 70 to 80 miles above the south line of the state.

Entering Kansas, the river runs for 140 miles, by general course, in a direction a little south of east; it then makes a bold curve to the northward, forming what is known as the Great Bend, after which it flows southeasterly. From Pueblo to the Great Bend, its width seldom exceeds 450 feet. The slope gradually decreases from nearly 15 to between 6 and 7 feet per mile. A single flouring-mill is returned as using the stream for power in Pueblo county, but further than that it is unemployed in this section. The bed is, to a large extent, quicksand; the stream itself is shallow, and inclosed by low banks, beyond which spreads a grassy bottom half a mile to 2 miles in width between bluffs. The latter rise 50 to 300 feet high above the stream, and are succeeded by the undulating surface of the prairie.

The peculiar features of this portion of the river and the adjoining valley are thus described by Mr. Tweeddale:

The bed is sand; the banks are low, but well defined, being somewhat rolling, with an inclination toward the river, as well as in the direction of its flow. * * * The soil of the valley is of Drift formation, formed of the detritus of the Rocky mountains, and is of varying character, with a predominance of sandy loam. The subsoil is mostly sand and gravel, and while the melting of mountain snows in June and July keeps the river banks full, the addition of storm waters of the violent rains in Colorado, amounting at times to from 2 to 3 inches in one hour, and which, falling upon an impervious water-shed, raise its tributaries, Purgatoire, Rule, Muddy, and Sand creeks several feet in an hour, does not cause the Arkansas river in Kansas to overflow even its low banks. The surplus water spreads out laterally, and is stored subterraneously in the adjacent porous subsoil. The same conditions exist with its tributaries in Kansas, particularly Pawnee, Walnut, and Cow creeks. To this is added the further peculiarity that while the streams in the Arkansas valley are relieved of their surplus waters by adjacent porous subsoil, the subsoil is in turn drained by the streams. Of this Cow creek is an instance, draining not only the subsoil, but also through it the Arkansas river.

As indicating the existence of this substratum of sand beneath the surrounding valley and continuous with the bed of the river, it is stated that wells sunk in the bottom-land strike water at the level of that in the Arkansas, and rise and fall with that stream.

Occasionally the Arkansas runs dry, although this has happened but once in the past five years. The last occurrence was in the spring, and, without any apparent cause, was followed by a sudden restoration of flow, which continued through the year. On such occasions as this the river is literally dry, there being very few pools, even, to be seen. The stretch most affected appears to be that between Sequoyah and Sedgwick counties, Kansas.

The principal tributaries received in Kansas are: From the north, Pawnee Fork, Walnut creek (of Barton county), Cow creek, Little Arkansas, Walnut creek (of Cowley county), and Grouse creek; from the south, Rattlesnake creek, Ne-Ne-Squaw river, and Slate creek. South of the Arkansas, near the Colorado line, Bear creek runs northeasterly toward the main stream, through Stanton county, but comes to an end 8 or 10 miles south of the river. Similarly, to the north, Poison creek runs easterly through Greeley and Wichita counties, but terminates its course in a basin or depression near the center of Scott county; its general direction is toward the headwaters of Pawnee Fork and Walnut creek, but whether there is any evidence of an underground connection with those streams I cannot say.

The Atchison, Topeka and Santa Fé railroad follows the river closely from Pueblo to Hutchinson, and then strikes off to the northeast toward the Missouri river. Along its course are numerous thriving towns, such as Dodge City, Larned, Great Bend, and Hutchinson, with populations of 1,000 to 1,500; farther down the river are Wichita, 4,000 inhabitants; Winfield, 2,800, and Arkansas City, 1,000.

East of Fort Dodge the country rapidly improves in fertility and in the extent of cultivation; while in 1878 Ford county showed less than half of 1 per cent. of its surface under cultivation, Reno county returned 17 per cent., Sedgwick 28 per cent., and Cowley 21 per cent. cultivated. (*a*) The principal productions in this section are winter wheat, corn, oats, and grass.

At Hutchinson, in Reno county; at Oxford, in Sumner county, and at Arkansas City, in Cowley county, the river is drawn upon for power, and these are the only points east of Pueblo county, Colorado, at which it is so employed; these powers will be described later in detail.

From Wichita to Arkansas City a thin growth of cottonwood and willows constitutes about all the timber that is to be found along the stream. The bed is largely of quicksand. In the vicinity of Wichita the river is 600 to 800 feet wide, and has a slope of about 3 feet to the mile. Passing down stream from Arkansas City more timber is found, comprising oak, hickory, pecan, walnut, hackberry, and on the low grounds close to the stream abundance of cottonwood. The banks and bluffs become high and rocky, and the river bed is more contracted. Toward the mouth of the Cimarron it grows wide and sandy again, and in places attains a width of 2,000 feet. (*b*) Of this part of the river Captain Bell, who led a detachment down its course in 1820, wrote:

Below the Cimarron we were all immediately struck with the change in the appearance of the water of the river. No longer of that pale clay color to which we have been accustomed, it has now assumed a reddish hue, hardly unlike that of the blood of the human arteries, and is still perfectly opaque, from the quantity of an earthy substance of this tint which it holds in suspension; its banks and bars are, from deposition, of the same color.

The river passes through the Indian territory in a tortuous southeasterly course, its slope gradually decreasing to less than 2 feet per mile. It receives numerous important accessions from tributaries, of which the principal are: On the east, Buck creek, Verdigris river, Grand or Neosho river, and Illinois river; on the west, Salt Fork, Red Rock creek, Black Bear creek, Cimarron river, Elk creek, Canadian river (the largest tributary), Sans Bois creek, and Poteau river.

The lower course of the Arkansas is bordered by wide alluvial bottoms, subject to overflow unless protected by levees. At Little Rock there is to be seen, on the north side of the river, a high rocky bluff of dark-colored slate, and a mile or two below on the south side a similar but much smaller exposure. These are called, respectively, the Big Rock and Little Rock, and are the last exposures on the river. Below Little Rock the Arkansas valley soon merges in the wide valley of the Mississippi. Below Fort Smith the chief tributaries are Lee's, Mulberry, Piney, Point Remove, and Cadron creeks on the north; and on the south side, Petit Jean and Fourche la Fave creeks.

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a Report Kansas State Board of Agriculture.

b See report of reconnaissance by J. D. McKown, *Report Chief of Engineers*, 1879.

Elevations and slope of the Arkansas river.

Locality.	Elevation above sea.	Distance between points.	Fall between points.	Fall between points.
	Feet.	*Miles.*	*Feet.*	*Ft. per mile.*
Source of river *	10,000			
		67	2,950	44.03
Cleora †	7,050			
		48	1,674	34.87
Cañon City †	5,376			
		40	663	16.57
Pueblo ‡	4,713			
		152	1,245	8.19
Granada ‡	3,468			
		133	969	7.29
Dodge City ‡	2,499			
		195	1,275	6.54
Wichita §	1,224			
		65	179	2.75
Arkansas City §	1,045			
		106	246	2.32
Mouth of Salt Creek §	799			
		77	145	1.88
Mouth of Cimarron river §	654			
		84	149	1.77
Near Fort Gibson ‖	505			
		127	122	0.96
Van Buren (7 miles below Fort Smith) ¶	383			
		265	161	0.61
Little Rock **	222			
		250	115	0.46
Mouth of river ††	107			

* Elevation as given by Humphreys and Abbot.
† Level of rails, Denver and Rio Grande railway.
‡ Level of rails, Atchison, Topeka and Santa Fé railroad.
§ Level of water surface. Distances and fall between stations from report of J. D. McKown. (See *Report Chief of Engineers*, 1870.)
‖ Low water at Missouri, Kansas, and Texas railway crossing.
¶ Low water by levels Saint Louis and San Francisco railway.
** Low water by levels Saint Louis, Iron Mountain and Southern railway.
†† Low water in Mississippi river. Levels of precision under Mississippi River Commission.

NOTE.—Distances above Wichita are measured upon land-office maps; distances below Fort Gibson are as given by Humphreys and Abbot.

I have but few data concerning the actual volume of the Arkansas. Major Suter states that the ordinary low-water discharge at the mouth, exclusive of White river, may be taken as approximately 3,000 cubic feet per second, and the ordinary high-water discharge as about 70,000 cubic feet per second.

Mr. McKown, in his report of a reconnaissance between Wichita and Fort Smith, gives the discharge at Arkansas City, in a very low stage, as about 675 cubic feet per second.

I was informed by Mr. Knight, consulting engineer of the works at Arkansas City, that the discharge assumed by him was about 600 cubic feet per second at extreme low water.

On the 5th of December, 1875, the volume at Hutchinson was measured by Mr. Tweeddale, and found to be about 1,500 cubic feet per second. The stage of river was described as "ordinary low water, 5 feet below high water", and it was stated that only in one or two instances during five years had the river been much lower.

The results of these different measurements may be thus summed up:

Discharge of the Arkansas river.

Locality.	Drainage area.	Volume, cubic feet per second.	Cubic feet per second per square mile.	Remarks.
	Sq. miles.			
Hutchinson, Kansas	30,000	1,500	0.039	Mr. Tweeddale's measurement; 5 feet below high water.
Arkansas City	44,500	600	0.014	Assumed by Mr. Knight; extreme low water.
Do	44,500	675	0.015	Measured by J. D. McKown; very low stage.
Mouth of river	160,000	3,000	0.019	Ordinary low water as estimated by Major Suter.
Do	160,000	70,000	0.437	Ordinary high water as estimated by Major Suter.

Considering that, in the Great Bend and above, the Arkansas has occasionally run dry, its volume in a low stage is evidently an uncertain quantity; it is probable, however, that over the section from Hutchinson to Arkansas City a volume of 600 to 1,000 cubic feet per second may safely be relied upon throughout all ordinary years.

The river is subject to three floods during the year—the first in January or February, the second in June or July, and the third in November; the second of these is the highest. In the upper river the slope is sufficient to pass the volume of water found there without overflow of the banks, and the range between high and low water is small, being only 7.45 feet at Wichita. The lower river has a moderate slope only, and there the oscillations are large. Toward the mouth the ordinary range between high and low water is 26 feet, and the extreme range 45 feet. At Little Rock the rise during the flood of 1844 was 33 feet.

Navigation is practically confined to the section between Fort Gibson and the mouth. Even there it is uncertain, in some years being good for eight months, while at other times low water has forced a suspension during an entire year. Aside from low water the most serious hindrance to navigation is from snags, which are contributed by the caving banks. In 1875 and 1878 successful attempts were made by private individuals in southern Kansas to transport grain down the river, and two or three trips were made in safety to Little Rock by small light-draught steamers. The portion of the river between Wichita and Fort Smith is so wide and shallow that its improvement for navigation would be difficult and expensive; the cost was estimated at $900,000 by Mr. McKown, assistant engineer (see *Report Chief of Engineers*, 1879).

Drainage areas of the Arkansas river.

Locality.	Square miles.	Locality.	Square miles.
Granite	391	Arkansas City, above Walnut creek	44,502
Helena, above Trout creek	778	Below Salt Fork	54,417
Cleora	1,440	Below Cimarron river	75,048
Cañon City, below Grape creek	3,051	Below Verdigris river	84,662
Pueblo, below Fountain creek	5,611	Below Neosho river	97,408
West Las Animas, above Purgatoire river	13,844	Below Canadian river	145,983
Granada, above Granada creek	23,086	Fort Smith, below Poteau river	149,265
Dodge City, including Poison Fork	29,238	Little Rock	157,466
Hutchinson, above Cow creek, but including Poison Fork	39,000	Pine Bluff	158,329
Wichita, below Little Arkansas	41,947	Mouth, not including White river	160,218
Oxford	44,036	Mouth, including White river	188,149

Ascending the river, the first and most important development of power on its course is met at Arkansas City, 4 miles north of the boundary of the Indian territory. It is a place of about 1,000 inhabitants, an important shipping point for Indian supplies, and is reached by a line of the Atchison, Topeka and Santa Fé railroad. The city lies upon the left of the Arkansas, on a point of bluffs formed where the valley of Walnut creek merges in that of the main stream. At very low stages the width of running water here does not exceed 200 feet; in a medium stage the river is 1,000 feet wide, and is confined between low banks 5 or 6 feet high. Farther back are the high banks, rising some 30 feet, and separated from each other by a total distance of 1,500 feet. The river bed is composed of quicksand 9 to 10 feet deep, underlaid by limestone of poor quality. The fall at this locality is about 2½ feet per mile.

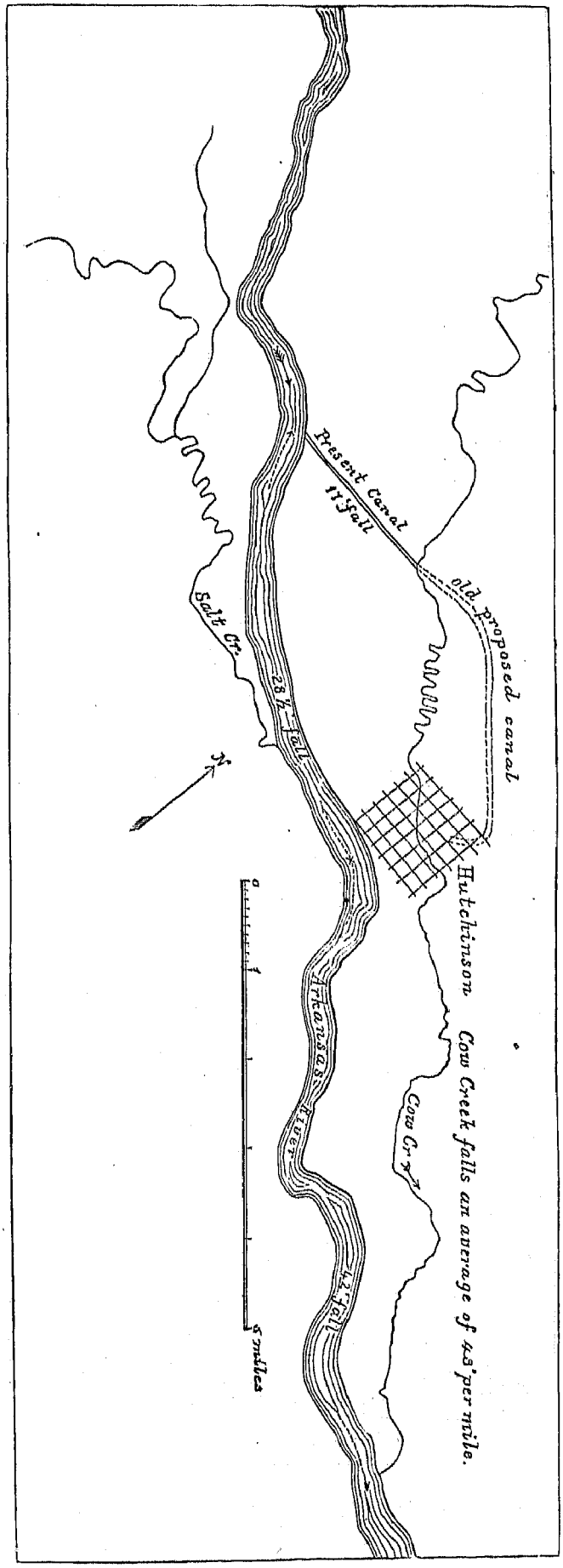
It was known for many years that there was a considerable difference of level between the river and the creek at points opposite the city, and by use of a carpenter's level the fall was determined to be 35 feet. A company was formed, and a consulting engineer engaged. An accurate line of levels was then run, and the fall found to be—not 35 feet—but a little more than 20 feet. The enterprise of developing the power was begun, however, and when the locality was visited by me, in the spring of 1881, was well under way. The general design includes a dam across the Arkansas, and a canal running thence, around the edge of the bluffs on which the city is built, to Walnut creek.

The dam is to be 700 feet long, 4 feet high, 44 feet wide at the base, and 12 feet wide at the top, and to consist of brush mattresses, arranged in successive layers. The mattresses used are 16 feet long, 4 feet wide, and 1 foot thick, the brush being bound in layers by short lengths of sapling which are wired together at their ends. The breast of the dam will be formed by a series of off-sets; the lowest of these is to be 12 feet, and this with the succeeding one of 8 feet will constitute an apron projecting 20 feet down stream. The two remaining off-sets are to be 1 foot each. Intermingled with the brush of the mattresses are hay and straw, designed to catch sediment, of which the Arkansas transports a large amount, and so render the structure compact and tight. It is expected that as the sand shall be scoured out from under the apron the latter, and possibly the entire dam, will gradually settle toward a firm bearing on bed rock.

The canal is designed to be about 2½ miles long, 4 feet deep, 15 feet wide at the base, and 27 feet wide at the top. It will have a grade of 2 feet to the mile, and an estimated capacity of 260 cubic feet of water per second. After allowing for the grade of the canal there remains an effective head of 19 feet, equivalent, with the above volume, to 560 theoretical horse-power. This will accommodate five or six flouring-mills carrying as many as five runs of stone each. But a small part of the ordinary flow of the river is thus utilized. By measurements previously given it is seen that even in unusually low water a discharge of between 600 and 700 cubic feet per second may be relied upon, or more than twice the estimated capacity of the present canal.

Although at the time of my visit the improvements had not been completed, the erection of one flouring-mill had already been decided upon by parties from Illinois, and it was desired to attract as many other establishments as possible to this point. The locality is well situated, in a good winter-wheat region; the climate is mild, rendering out-door labor possible throughout the year, and abundant supplies of wool are to be obtained near at hand.

The next power on the river is at Oxford, a small place of 400 inhabitants, about 40 miles below Wichita, on the west bank. The mill is located on an old slough and obtains a head of 10 feet, but uses only a small portion of the available power; it carries five runs of stone and has a capacity of 150 barrels of flour per day. The slough is 2½ miles long, the lower half mile serving as tail-race; having become somewhat filled with sediment, a low rude



WATER PRIVILEGE AT HUTCHINSON.

dam of brush and stone was thrown across the main river, so as to divert water to the mill; the effect has been to scour out the deposit of sediment, so that the dam will soon be unnecessary. The mill is entirely out of reach of floods, and is not troubled to an appreciable extent by backwater.

Above Oxford no power is used from the Arkansas till we reach Hutchinson, in Reno county. This city lies upon the north bank of the Arkansas, on the line of the Atchison, Topeka and Santa Fé railroad, and has a population of about 1,500. The river is here 1,600 to 1,700 feet wide between banks, and has a fall of over 5 feet per mile. Passing through the city is Cow creek, which rises some 55 miles to the northwest, in Barton county. It is a small, crooked stream, only 40 or 50 feet wide; its lower course lies for a considerable distance in the bottom-land of the Arkansas, and for the last 12 or 15 miles an interval of less than 2 miles separates the streams. The descent of the creek being less rapid than that of the river, it happens that, at a point 3 or 4 miles above Hutchinson, there is a difference of level between them of 17 feet. Across the intervening space a canal has been dug, about 2 miles long and using up in this distance the entire fall of 17 feet; it has a width of 40 feet, and with its large slope the water has a rapid current. By raising the banks of the canal a large part of its fall could be utilized for power at the point of entering Cow creek. The original design was to bring water from the creek (re-enforced, if necessary, by means of a canal from the Arkansas) through a long race running east of the course of the former stream. It is said that a fall of 16 feet would thus be rendered available, due simply to the natural descent of the creek. This plan was not, however, carried out.

As now arranged, the water runs down the channel of the creek some 3 miles, to what is known as the "First Water-Mill", at Hutchinson. This mill has 10 feet head, five runs of stone, and uses 60 horse-power. Power is also employed by a small corn-mill. The privilege which I have described has been easily improved, and is well situated. It is entirely out of reach of backwater from the main river, and its supply from that source is easily controlled by head-gates at the entrance of the canal. Formerly there was a low dam across the river at that point, only 18 inches high, and merely designed to divert water into the canal. It consisted of two rows of sheet-piling, 10 feet apart, simply driven into the sand without reaching any firmer bearing. They were joined at the top by capping pieces, the whole being surmounted by a low framed structure filled in with stone. The dam was of light construction, no timbers larger than 4 inches square being employed. A rude apron of plank protected the river bed below the dam. The structure remained in good condition for two years and was then partially carried away; but as the head-gates now opened 2½ feet below the water surface there was no longer any necessity for a dam, and it was entirely removed.

But a small fraction of the entire available power at Hutchinson is utilized. Assuming a low-water discharge of 600 cubic feet per second, this is equivalent, with a head of 10 feet, to 680 theoretical horse-power; and during the greater portion of the year the power is much larger. By using proper means to divert water into a canal, which should run with moderate slope from the Arkansas to the creek, or by raising the banks of the present canal sufficiently, a series of valuable powers could undoubtedly be formed.

The Arkansas is not used for power at any point in Kansas above Hutchinson, and only two mills are returned upon the stream in Colorado. Its rapid descent and the freedom of its banks from overflow are advantageous, but the wide channel and treacherous sandy bed are very unfavorable to improvements for power. The best methods of using the stream seem to be those employed at Hutchinson, Oxford, and Arkansas City, and it is not improbable that similar opportunities exist at other points. Near Hutchinson, on the south side of the Arkansas, a small stream called Salt creek empties, its lower course lying for some distance near the main river. It is claimed that a power might be developed there in the same manner as at Hutchinson, and such an improvement has, indeed, been discussed.

Principal tributaries of the Arkansas river.

[In order from the mouth.]

Stream.	Drainage area.	Stream.	Drainage area.	Stream.	Drainage area.
	Sq. miles.		*Sq. miles.*		*Sq. miles.*
White river	27,925	Cimarron river	18,407	Pawnee Fork	2,633
Fourche la Fave creek	1,133	Black Bear creek	628	Two Butte creek	1,217
Cadron creek	772	Buck creek	205	Big Sandy creek	3,722
Point Remove creek	495	Red Rock creek	514	Purgatoire river	3,002
Petit Jean creek	968	Salt Fork	6,940	Horse creek	1,310
Illinois creek	392	Grouse creek	401	Timpas creek	459
Piney creek	550	Walnut creek	2,005	Apishpa river	1,156
Mulberry river	469	Slate creek	315	Huerfano river	1,791
Poteau river	1,068	Ne-Ne-Squaw river	2,282	Chico creek	883
San Bois creek	727	Little Arkansas river	1,287	Saint Charles river	562
Canadian river	46,221	Cow creek	709	Fountain qui Bouille creek	981
Elk creek	387	Rattlesnake creek	720	Oil creek	432
Illinois river	1,470	Poison creek*	1,719	Grape creek	536
Neosho river	12,746	Walnut creek (empties near Great Bend)	1,784	Currant creek	310
Verdigris river	8,010				

*Does not reach the main river.

THE WHITE RIVER AND TRIBUTARIES.

The main fork of White river rises in northwestern Arkansas, near the southern boundary of Madison county. The river pursues a very crooked course, and leaves the state at a point about 50 miles due north of its source; flowing through Barry, Stone, and Taney counties, Missouri, it re-enters Arkansas about 40 miles east of the locality where it previously left the state, and continuing thence in a southeasterly and southerly direction joins the Arkansas near its mouth. It is 360 miles long by general course, but its actual length is probably more than twice as great.

The area drained by this river comprises 27,925 square miles, and includes a large part of northern Arkansas and an important section in southern Missouri. Three varieties of surface are presented—lowland, prairie, and mountains. For 80 miles, more or less, above the mouth the country is low, swampy, and subject to frequent overflows. It is covered with a heavy growth of oak, ash, walnut, poplar, beech, and gum. The soil is rich, and, where above overflow, yields fine crops of cotton, wheat, corn, rye, and oats. To the west of this section the country becomes hilly, and is in part timbered and in part an open prairie. The timber is mainly hard wood. The bottoms are very productive in cotton, corn, and tobacco; the uplands are less fertile, but are well suited to grain, and are especially valuable for grazing.

Advancing westward from the central part of Arkansas, the surface grows more and more hilly, then quite rough and broken, and finally rises to the summits of the Ozark mountains, among which White river heads and runs its upper course. These mountains cross the northwestern part of the state, and then extend easterly through southern Missouri. They seldom rise more than 500 to 1,000 feet above their bases, or more than 1,500 to 2,000 feet above sea-level. They do not exist throughout as a regular and continuous range, but largely as disconnected knobs and peaks, with frequently very rocky, precipitous slopes. They are chiefly composed of limestone, sandstone, granite, greenstone, and clay slate. The main ridge is thickly timbered with oak, while south of it, in Missouri, there is a great deal of pine. The elevated districts comprising this portion of the White River basin have a healthful climate, but generally a shallow and poor soil. They are, however, very rich in mineral resources, such as iron, lead, and zinc, and contain deposits of copper, nickel, cobalt, and tin. The streams are clear, cool, swift-running, and well sustained by springs.

According to the statistics of Mr. Gannett, the population of White River basin increased from about 291,000 in 1870, to about 461,000 in 1880. Advancing up stream the more important towns on the river are: Augusta, population about 700; Jacksonport, 700; Batesville, 1,300; Forsyth, 300; and Fayetteville, 1,800. It is seen that, considering the length of river, there are few places of much consequence. The greater part of the country drained by this river is, in fact, sparsely settled and very difficult of access. The Memphis and Little Rock, and the Saint Louis, Iron Mountain and Southern railroads cross the lower river; in Missouri, the Saint Louis and San Francisco line approaches within about 30 miles of its course, and a partially-completed branch of the same road passes southerly through Fayetteville, follows closely the West Fork of White river, and after piercing the Boston mountains continues southwesterly to Fort Smith, on the Arkansas river.

Above Forsyth White river is a clear, rapid stream. Its valley is contracted, the bottom-land narrow and showing but few spots suited to cultivation. The banks are of good height, with frequent rock exposures; the bed is generally rocky, consisting mainly of limestone, with more or less cherty quartz. The river is in this section 200 to 300 feet wide, 2 to 5 feet deep in an ordinary stage, and is a constant succession of shoals, but without any abrupt falls. It is subject to heavy freshets, with a rise of 10 to 12 feet above low water.

Below Forsyth the neighboring country continues hilly and rough for 200 miles down stream, or to the vicinity of Batesville. "The hills and rock bluffs are very high and precipitous. The bottom-lands are narrow, generally upon one side of the river at a time, and seldom over one-half mile in width."(*a*) The banks are firm, and the width of the stream at low water is about 400 feet. There are no abrupt falls, but occasional rocky shoals with a few feet of descent. At Elbow shoals, some 50 miles below Forsyth, there is an estimated fall of 4 feet in 1,000 feet. In this portion of White river the bottom-land is 20 to 25 feet above low water, while the extreme freshet rise is reported to be 28 feet.

Below Jacksonport, and thence to the mouth, the country adjoining the river is low, and during high water is submerged to a depth of from 3 to 10 feet. The bottom-lands are cultivated in some places, but they usually display a heavy growth of timber and cane-brakes, and are intersected by many bayous and swamps. The average width of this portion of the stream varies for different sections from 350 to 500 feet. The highest recorded rises in White river have been those of 1844 and 1867. The top of the 1844 flood was 27 feet above low water at Saint Charles; in 1867 the river rose 29½ feet at that point, and 29¼ feet at Jacksonport, overflowing the latter town 2 feet, and the adjacent country 3 to 10 feet, in depth. Lowest water usually occurs in July, August, and September; the regular rises are in spring and fall, and a fair stage of water prevails through the winter.

With an ordinary depth of water the river is navigable to Batesville, 380 miles by water from the mouth. Contemplated improvements will soon, it is thought, extend navigation nearly to the mouth of Buffalo Fork, and afford an outlet to what is known as the Yellville country. Eventually navigation may be carried to Forsyth, 590

a See report by A. Livermore, *Report Chief of Engineers*, 1871.

miles from the mouth. Below Jacksonport the chief obstructions are occasional gravel shoals, snags, and some wrecks. Between Jacksonport and Forsyth there are more or less snags and overhanging trees, but the most serious obstructions are a series of rocky shoals. At Buffalo shoals, the worst of these, work was begun by Major Suter in 1878, the design being to increase the depth at the shallowest points by building seven spur-dikes of stone, and in the *Chief of Engineers' Report* for 1880 three of these are stated to have been completed, with good results.

Elevations and slope of the White river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Head of West Fork †	1,898	625	80	7.81
Range 30, township 15, section 32 ‡	1,273	708	177	4.00
Forsyth §	565	152	100	1.52
Point 400 miles from mouth §	413	143	100	1.43
Point 300 miles from mouth §	270	77	60	1.28
South of Jacksonport ‖	193	86	**330	0.26
Mouth of river ¶	107			

* By map measurement above Forsyth; below that point as given by government engineers.
† Top of gap in Boston mountains, tunneled by Saint Louis and San Francisco railway, range 30, township 13, section 13.
‡ Low water by Saint Louis and San Francisco railway levels.
§ Distances and elevations as estimated by Mr. Livermore, in report previously referred to; elevations unreliable.
‖ Low water at Saint Louis, Iron Mountain and Southern railway crossing.
¶ Low water in Mississippi river by levels of precision under Mississippi River Commission.
** Approximate.

There are no long-continued records of rainfall at points in the White River basin, but from the Smithsonian rain-charts I should estimate the average downfall for the entire basin at about 13½ inches in spring, 11 in summer, 10 in autumn, 9 in winter, and 43½ for the year. The amount for the upper basin seems to be slightly less in each of the seasons, and is about 39½ inches for the year. No accurate determinations have been made of the volume of flow in the river. Major Suter states that the discharge in ordinary low water may be taken as approximately 3,000 cubic feet per second near the mouth, and 50,000 cubic feet per second in ordinary high water. During the examination of the upper river in 1870 its volume was measured by Mr. A. Livermore, assistant engineer, and found to be 264 cubic feet per second at a point 67 miles, by river, below Forsyth. These various results may be thus presented:

Discharge of the White river.

Locality.	Drainage area.	Volume, cubic feet per second.	Cubic feet per second per square mile.	Remarks.
	Sq. miles.			
Mouth of river	27,025	3,000	0.1074	Ordinary low water, as estimated by Major Suter.
Mouth of river	27,025	50,000	1.7010	Ordinary high water, as estimated by Major Suter.
Sixty-seven miles below Forsyth	5,511	264	0.0480	Measurement by A. Livermore. River said to have been lower at the time than ever before.

The meager railroad facilities, and lack of time for slower methods of traveling, prevented me from gaining full information as to the value for power either of the main river or most of its tributaries. I judge, however, that the upper portion of White river presents real advantages for use in its rocky bed and banks, considerable fall, and a volume of fair size. The freshet rises are sudden and large, but probably no more serious than on many rivers in extensive use. Hitherto there has been no demand for power in this section, except by occasional small saw- or grist-mills, and these have been located upon the little streams, which are more easily and cheaply controlled than the main river. The difficulty of access, and sparse settlement, have also been hindrances to development, but will gradually disappear, as the country is being opened up by the Saint Louis and San Francisco railway extension. The famous Eureka Springs have already attracted a population forming an important town. The only mills on White river are a small flouring- and grist-mill in Benton county, and a flouring-, grist-, and saw-mill in Madison county. There are a great many mills on the various tributaries, as shown in the table of utilized powers, but they are all of small size. Those streams draining the slopes of the Ozark mountains are probably the most reliable and valuable of all the tributaries, while those farther down stream, in eastern Arkansas, are sluggish and of little use.

Estimated volume and horse-power of the upper White river.

Locality.	Drainage area.*	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Below War Eagle Fork	979	40	45	70	80	150	170
Below King's river	2,095	80	91	150	170	310	352
Below James' Fork	3,589	150	170	280	318	500	636
Forsyth, below Swan creek	4,463	200	227	350	398	700	795

*Drainage area below Crooked creek, 6,576 square miles; below Buffalo Fork, 7,955 square miles; below Black river, 20,734 square miles.
NOTE.—Rainfall on the upper basin about 12½ inches in spring, 10 in summer, 9½ in autumn, 7½ in winter, and 39½ for the year.

Drainage areas of the principal tributaries of the White river.

Stream.	Drainage area.	Stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
La Grue river	507	Buffalo Fork	1,346
Big creek	850	Crooked creek	454
Cache river	1,905	Big Beaver creek	435
Bayou des Arcs	717	Long creek	318
Little Red river	1,243	James' Fork	1,354
Black river	8,810	King's river	610
Old Fork	687	War Eagle Fork	344
Big North Fork	1,800	Main and West Forks, above War Eagle Fork	635

La Grue river drains portions of Prairie and Arkansas counties, and enters White river from the west. Its upper course is through what is called Grand prairie, said to be almost destitute of springs.

Big creek runs through a low region on the east side of the main river, heavily timbered, swampy, and subject to overflow.

Cache river drains a long narrow strip, similar in character to the country just described.

Little Red river (*a*) runs easterly through Van Buren county, and southeasterly through White county, emptying into White river from the west. It is about 95 miles long by general course, and drains a rolling prairie surface with considerable timber. For nine months in the year small boats can ascend the river 30 miles, to West Point, and during three of those months advance 18 miles farther, to Searcy Landing. At a low stage the amount of water flowing is small, and navigation is obstructed by shoals, snags, and leaning trees. From Searcy Landing to West Point the river bed is generally rocky, with several shoals, varying from 130 feet in length, with 2.05 feet fall, to a mile and a half in length, with 0.8 foot fall. The stream is in this section 250 to 300 feet wide between banks, with a low-water depth of 3 to 9 inches on the shoals. Between the shoals are pools, some miles in length, with sandy bed and a depth of 2 to 16 feet. The banks are wooded, composed of firm clay, and range from 25 to 45 feet in height above low water. In places where the river approaches the bluffs the banks are rocky, steep, and high. The country adjoining the lower river is heavily wooded, and is overflowed during high water.

Low water occurs in July, August, and September. A freshet rise of short duration takes place in spring, usually in May or the latter part of April, and there are occasional short rises in fall and winter. The oscillations are often very rapid, and it is said that the river will sometimes rise 15 or 20 feet in twelve hours, and again within an equal length of time regain its former level. The highest recorded freshet was that of 1867, when the rise was 39.3 feet at Searcy Landing, and 29.3 feet at West Point.

THE BLACK RIVER.

Black river is the principal tributary of the White, having a length, by general course, of about 170 miles, and a drainage area of 8,810 square miles. Its source is in Iron county, Missouri, a short distance west of the headwaters of the Saint Francis, and the two streams run approximately parallel. Black river empties into the main stream in Jackson county, at the point where the latter changes its course from southeast to south. After entering Arkansas it receives several tributary streams from the northwest, which also head in southeastern Missouri, and which, together with the main Black, drain the southern slope of the Ozark mountains. This portion of the basin is rough and broken, well-timbered with pine and oak, and contains valuable deposits of iron, lead, copper, and

a Information obtained from report by Mr. Justin Straszer. See *Report Chief of Engineers* for 1871.

zinc. The lower river is very winding, and runs through low bottom-lands subject to overflow; the high lands beyond are cultivated and yield good crops of cotton. The valley is thickly timbered with cypress, white oak, black walnut, and, in Missouri, poplar.

The river is navigable to Corning in ordinary water, and it is designed to extend navigation to Poplar Bluffs, (*a*) to which even now some boats ascend in high water, and which is a shipping point of some importance for lumber. The Saint Louis, Iron Mountain and Southern railway follows the general course of the river, seldom more than a few miles distant from it, and much of the way skirting it closely; with this exception, the Black River basin has no railroad facilities. The country is rather sparsely settled and contains no large towns; Pocahontas, Corning, and Poplar Bluff are the most important places on the river, but the latter of these, which is the most populous, has only about 800 inhabitants.

Elevations on the Black river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Mill Spring*	418	101	†34	2.97
Near Poplar Bluff‡	317			
Mouth of river§	195	122	‖311	0.39

* Low water by levels of Saint Louis, Iron Mountain and Southern railway.
† Map measurement.
‡ Low water at crossing of Saint Louis, Iron Mountain and Southern railway.
§ Estimated from elevation at Saint Louis, Iron Mountain and Southern railway crossing below.
‖ From government engineers' report.

At Poplar Bluff, and for some distance above, the average width of the river is about 150 feet; the banks are rather low, and succeeded by bottom-land. Farther up stream, however, the banks are higher, the bed is gravelly, and there is a swift current, with numerous shoals. The Black, Little Black, Current, Eleven Point, and Spring rivers are said to have a general similarity. They are used only to a very small extent for power, but there are a considerable number of mills, in the aggregate, on their various minor tributaries; they are mostly flouring- and grist-mills of small size. These streams are clear and swift running, with gravelly beds in their middle courses and considerable rock in the upper waters. They are largely fed by springs, are steady in flow, and would furnish powers of good size. Some of the springs in this portion of Missouri are of sufficient volume to immediately supply power to small mills. At Mill Spring, in Wayne county, a mill is run in this way by water from a large spring which gushes out from the base of a bluff only a few hundred feet away. There is said to be another mammoth spring at the source of Spring creek.

Aside from the poor railroad facilities, the main objection to the larger tributaries of the Black and, indeed, to that stream itself, for power, lies in their being visited by heavy freshets, during which they overflow the bottoms extensively, and inflict much damage upon the farming lands by washing out the soil. The overflows are not so serious in the upper waters as below, and it is those portions which are, therefore, most favorable to use. At Mill Spring, on Black river, the range of the latter between extreme high and low water is 19 feet; near Poplar Bluff it is 22 feet, and near the mouth 31 or 32 feet.

Estimated volume and horse-power of Black and Current rivers.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
BLACK RIVER.	*Sq. miles.*						
Mill Spring	1,003	150	170	180	204	240	273
Poplar Bluff	1,315	190	216	230	261	320	364
CURRENT RIVER.							
Above Jack's Fork	784	110	125	140	159	190	216
Van Buren	1,730	250	284	310	352	420	477
Doniphan	2,388	350	398	420	477	580	659

NOTE.—Drainage area of Current at mouth, 2,935 square miles; Eleven Point, above junction with Spring, 992 square miles; Spring river at Canton, 1,034, and below Eleven Point, 2,333, square miles; Strawberry, at mouth, 740 square miles.

a Major W. H. H. Benyaurd, corps of engineers, estimates the expense of improving the stream from Poplar Bluff to the mouth at $90,000; $15,000 was appropriated by Congress in 1880. (See *Report Chief of Engineers*, 1880.)

Power utilized on the White river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
White	Arkansas	Arkansas	Benton	Flour, grist, and saw	1	14	30
Do	do	do	Washington	Saw	1	8	12
Black	White	Missouri	Wayne	Flour and grist	1	15	18
Do	do	do	Reynolds	do	1	4½	10
Strawberry	Black	Arkansas	Lawrence	Cotton-gin	1	5	20
Do	do	do	Sharp	Flour and grist	1	8	15
Do	do	do	Izard	do	1	6	16
Small streams	Strawberry	do	Lawrence	do	1	7	7
Do	do	do	Sharp	do	6	45	93
Do	do	do	do	Saw	3	22½	39
Do	do	do	do	Cotton-gin	1	7	10
Spring	Black	do	Fulton	Woolen	1	6	6
Do	do	do	do	Flour and grist	1	6	30
Do	do	do	do	do	2	16	35
Small streams	Spring	do	Randolph	do	3	12	36
Do	do	Missouri	Oregon	do	2	17	40
Do	do	do	do	Flour, grist, and saw	1	7	24
Current	Black	do	Ripley	do	1	5	25
Do	do	do	do	Flour and grist	1	.....	20
Do	do	do	Shannon	Saw	1	9	6
Small streams	Current	do	Ripley	Flour and grist	2	10	21
Do	do	do	do	Flour, grist, and saw	1	6	14
Do	do	do	Shannon	Flour and grist	3	27½	36
Do	do	do	Texas	do	2	11	14
Do	do	do	Dent	do	2	12	17
Do	do	do	do	Flour, grist, and saw	1	9	55
Do	do	do	Butler	Flour and grist	1	7	16
Do	Black	Arkansas	Independence	do	1	8	20
Do	do	do	Randolph	Woolen	1	4	.....
Do	do	Missouri	Butler	Flour and grist	1	7	12
Do	do	do	Reynolds	do	2	18	48
Do	do	do	do	Saw	2	24	62
Do	do	do	Iron	Flour and grist	1	6	18
Big North Fork	White	do	Douglas	do	2	26	16
Do	do	do	do	Saw	1	.....	20
Sundry streams	Big North Fork	do	do	do	1	5	10
Do	do	do	do	Flour, grist, and saw	1	6	32
Do	do	do	do	Flour and grist	5	35	48
James Fork	White	do	Christian	do	1	6½	12
Sundry streams	James Fork	do	Stone	do	6	67	100
Do	do	do	Barry	do	3	18	28
Do	do	do	do	Saw	1	9	20
Do	do	do	Christian	Flour and grist	2	13	46
Do	do	do	do	Woolen	1	6	4
Kings	White	Arkansas	Carroll	Flour and grist	1	8	6
Do	do	do	Madison	do	1	10	20
Small streams	Kings (?)	do	Carroll	do	3	26	34
Do	do	do	do	Cotton-gin	1	7	8
Do	White	do	White	Flour and grist	4	35	52
Do	do	do	Van Buren	do	2	.....	40
Do	do	do	do	Saw	1	24	15
Do	do	do	Independence	Woolen	1	10	8
Do	do	do	do	Flour and grist	8	54½	170
Do	do	do	do	Saw	1	8	25
Do	do	do	do	Saw and cotton-gin	1	10	50
Do	do	do	Izard	Flour and grist	1	7	16
Do	do	do	Baxter	do	2	17	25
Do	do	do	Marion	do	2	8	40
Do	do	do	Boone	do	3	18	26
Do	do	do	Newton	do	4	76	47
Do	do	do	do	Woolen	1	.....	5
Do	do	Missouri	Ozark	Saw	1	9	10
Do	do	do	do	Flour and grist	1	6	10
Do	do	do	Douglas	do	1	7	40
Do	do	do	Taney	do	4	24½	112
Do	do	do	do	Flour, grist, and saw	1	10	28
Do	do	do	Christian	Flour and grist	1	.....	7
Do	do	do	Barry	do	2	22	56

Power utilized on the White river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Small streams	White	Missouri	Barry	Woolen	1	16	24
Do	do	Arkansas	Benton	Flour and grist	1	31	8
Do	do	do	do	Saw	1	10	7
Do	do	do	Madison	Flour and grist	3		52
Do	do	do	Washington	Woolen	1	16	4
Total					130	1,031	2,146

THE CANADIAN RIVER.

This river, the largest tributary, in point of area drained, of the Arkansas, is formed by small streams rising on the eastern slopes of the Rocky mountains, near the boundary between Colorado and New Mexico. From the source of Vermejo creek, in San Francisco pass, it runs for about 140 miles in a direction somewhat east of south; it then turns and pursues a winding easterly course across the northwestern portion of Texas and a great part of the Indian territory, in which latter it unites with the Arkansas, some 70 miles by river above Fort Smith. It has a length, by general course, of between 700 and 800 miles, and a drainage area of a little more than 46,000 square miles. The population of this entire area is but about 22,500, (*a*) and it is only reached by railroads at the extreme headwaters and near the mouth.

The following description is that given by Major Long, who explored the river in 1820, and is taken from Humphreys and Abbot's report:

This river has a broad valley, bounded by bluffs from 200 to 500 feet high, faced with rocky precipices near its source, and presenting abrupt declivities, intersected by numerous ravines lower down. It has a spacious bed, depressed but a few feet below the bottoms, and exhibiting one continued stratum of sand through the greater part of its length. It is the channel through which the water of a vast extent of country is carried off; yet, during most of the summer season it is entirely destitute of running water throughout a large proportion of its extent—a circumstance in proof of the aridity of the region drained by it. Fifty miles above its mouth, it receives at least two-thirds of its water from its principal tributary, denominated the North Fork. This fork rises between the Arkansas and Canadian, and has a meandering course of about 700 miles. Six miles above the fork just mentioned another tributary enters the Canadian, called the South Fork, about half as large as the other. Notwithstanding the supplies afforded by these two tributaries, the Canadian has not a sufficiency of water in summer to render it navigable even to their mouths.

Major Long further describes the river as bordered by fertile bottoms near its mouth, its valley containing an abundance of timber for 200 miles above. Passing still farther westward, however, the soil becomes sandy, even in the bottoms, vegetation is scant, and the waters of the river are brackish from the presence of common salt and sulphate of magnesia.

Drainage areas of the Canadian river and tributaries.

Stream.	Drainage area.	Stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Vermejo creek	594	Little river	942
Cimarron river	1,096	South Fork	824
Mora river	1,725	North Fork	15,122
Rio Conchas river	1,193	Canadian, at Fort Butler, below Arroyo de la Cinta	8,482
Ute creek	1,679	Canadian, below Deer creek	26,219
Deer creek	312	Canadian, at mouth	46,221

THE NEOSHO RIVER. (*b*)

Rising in Morris county, in eastern Kansas, the Neosho takes a southeasterly and then southerly course, and entering the Indian territory joins the Arkansas at Fort Gibson. It is 260 miles long by general course, and has a drainage area of 12,746 square miles, comprising portions of Kansas, Missouri, the Indian territory, and a small part of northwestern Arkansas. The surface is mainly prairie, and is exceedingly rich farming land, especially in the bottoms; the principal productions are wheat, corn, and oats. The river is quite thickly fringed with timber, which forms a belt 1 mile to 5 miles in width, narrowing in the upper course; the more common varieties of trees are black walnut, cottonwood, sycamore, hickory, pecan, burr-oak, black oak, and soft maple. The timber is said to be

a Statistics by Mr. Gannett in *Census Bulletin* No. 78. *b* Also called Grand river.

found most plentifully on the east side of the stream and this is claimed to be a common feature with the rivers of that section, and is explained by the prevailing westerly and southwesterly winds having driven the prairie fires toward the windward bank, while the leeward bank has been protected by the water. Where cultivation has put an end to prairie fires the timber spreads out on both sides into the prairie. A good quality of bituminous coal exists in southeastern Kansas, and is found along the Neosho. Building-stone is abundant and valuable, and includes sandstone, blue limestone, common limestone, and in the upper valley a beautiful white magnesian limestone, so soft when quarried that it can easily be sawed, chiseled, or planed, but which becomes hard on exposure. Rich deposits of lead and zinc are also found in the section drained by Spring river, in southwestern Missouri.

The Missouri, Kansas and Texas railway follows the general course of the river throughout its length, and it is also reached by various other lines. The valley is well settled, and the more important towns on the river, advancing up stream, are Chetopa, population, in round numbers, 1,300; Oswego, 2,400; Osage Mission, 1,300; Chanute, 900; Humboldt, 1,500; Iola, 1,100; Burlington, 2,000; Emporia, 4,600, and Council Grove, 1,000.

Elevations and slope of the Neosho river.

Locality.	Elevation above sea.	Fall between points.	Distance between points.*	Fall between points.
	Feet.	*Feet.*	*Miles.*	*Ft. per mile.*
Emporia†	1,101			
		105	40	2.63
Burlington†	1,050			
		102	41	2.49
Humboldt†	954			
		40	76	0.53
Oswego†	914			
		414	152	2.72
Mouth of river‡	500			

* Map measurement.
† Level of rails, Missouri, Kansas and Texas railway.
‡ Water surface, estimated from elevation of Arkansas river at Missouri, Kansas and Texas railway crossing.

The Neosho is quite a crooked river, and meanders back and forth through bottom-land, which ranges from 1 mile to 5 miles in width, and which rises by successive terraces to bluffs of moderate height. The banks are usually of soil, and are firm; now and then loose slate and soapstone are exposed where the river approaches the bluffs. The height of the banks is seldom less than 10 feet, and varies from that to 75 feet where bluffy. The bed in the vicinity of Oswego is a shale, not very firm. The river is there 200 feet wide, and 2 to 6 feet deep, in an ordinary stage; it has a swift current, and is a succession of pools and shoals of moderate slope. It is generally frozen over from January to March; sometimes the ice is no more than half an inch thick, but in the severe winter of 1880–'81 it formed to the depth of 10 inches.

Unexpected rises may occur at any time, but the annual high water is in May and June, and results from the heavy rains of that period. The stream rises rapidly, often 2 feet or more in a day, and is also quick to subside, having been known to fall 8 feet in a day at Oswego; the greatest recorded rise at that point is 22 feet. The banks have been overflowed extensively only twice in ten years. During high water the river sets up over the dams so as to hide them entirely from view; large amounts of drift are brought down, though not so much, it is said, as formerly; it passes over the dams without injuring them. An old resident of Neodesha, who formerly lived for some years by the Neosho, informed me that in 1860 the stream ran dry for six months, and that it was again dry in 1862 and 1864. There have been no such occurrences in recent years, and it is not probable that any will be noted again, for the country is now broken up by cultivation, the soil rendered receptive of water, and the streams are thereby made more steady.

There are flouring-mills on the Neosho at intervals all along its course above Oswego. They are reported to carry from two to six runs of stone each, and to have an abundance of water at all seasons. At Oswego there is a crib-work dam, filled with stone, 200 feet long and 7 feet high; it rests upon a rock foundation and has crib-work abutments. The race is about 450 feet long, 20 feet wide, and is built out into the stream, from which it is separated by a crib-wall; it fills up with loose shale and soapstone, and has to be cleaned out every year. With a new dam 10 feet head might be created at this privilege, but with the present structure only 6 feet is in use. About 60 horse-power is employed at Howell & Hall's flouring-mill.

In its upper course the Neosho receives from the west Cottonwood river, which runs easterly through Marion, Chase, and Lyon counties. This is about 80 miles long by general course, and, as shown by railroad levels, falls in the neighborhood of 170 feet between Florence and the mouth. It is about 120 feet wide near the latter, and is used for power at various points along its course by flouring-mills. The flow is quite uniform, but the mills are liable to be short of water in August and September.

Spring river, which drains several counties in southwestern Missouri, joins the Neosho from the east in the Indian territory, and is an important mill stream.

Drainage areas of tributaries of the Neosho river.

Stream.	Drainage area.	Stream.	Drainage area.
	Sq. miles.		*Sq. miles.*
Cottonwood, at Florence	598	Spring river, at mouth	2,669
Cottonwood, at Cottonwood Falls	1,356	Elk river	874
Cottonwood, at mouth	1,934	Cabin creek	609
Spring river, at Carthage	472	Spavina creek	201
Spring river, at Georgia City	1,101	Pryor creek	299
Spring river, at Empire City	1,915	Spring creek	291

Estimated volume and horse-power of the Neosho river.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Below Cottonwood	2,726	60	68	110	125	180	204
Le Roy	3,212	70	80	130	148	220	250
Humboldt	4,121	110	125	160	182	280	318
Osage Mission	4,630	130	148	180	204	310	352
Oswego	5,228	150	170	200	227	350	398

NOTE.—Average rainfall on the section considered about 10½ inches in spring, 14 in summer, 8 in autumn, 5½ in winter, and 38 for the year.

Power utilized on the Neosho river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Neosho	Arkansas	Kansas	Labette	Flour and grist	1	6	60
Do	do	do	Cherokee	Saw	1	4½	10
Do	do	do	Neosho	Flour and grist	2	14	72
Do	do	do	Allen	do	2	15	145
Do	do	do	do	Furniture	1	.....	45
Do	do	do	Woodson	Woolen	1	7½	18
Do	do	do	do	Flour, grist, and saw	1	8	58
Do	do	do	Coffey	Flour and grist	1	14	130
Do	do	do	do	Flour, grist, and saw	1	8	60
Do	do	do	Lyon	do	2	13	110
Do	do	do	do	Flour and grist	1	8	35
Do	do	do	Morris	do	1	8	75
Spring	Neosho	do	Cherokee	do	4	20½	140
Do	do	Missouri	Jasper	do	6	42	352
Do	do	do	do	Flour, grist, and saw	1	7	37
Do	do	do	do	Saw	2	13	80
Do	do	do	Lawrence	Woolen	1	8	13
Do	do	do	do	Flour and grist	3	28	62
Sundry small streams	Spring	do	Jasper	do	3	24½	100
Do	do	do	do	Saw	1	11	20
Do	do	do	do	Flour, grist, and saw	1	6	40
Do	do	do	Lawrence	Flour and grist	1	9½	5
Do	do	do	Newton	do	8	66	228
Do	do	do	do	Flour, grist, and saw	1	8	70
Do	do	do	do	Woolen	1	.....	8
Do	do	do	Barry	do	1	10	10
Do	do	do	do	Flour and grist	3	48	64
Do	do	do	McDonald	do	2	16	57
Do	do	do	do	Flour, grist, and saw	2	16	167
Cottonwood	Neosho	Kansas	Lyon	do	1	7	73
Do	do	do	do	Flour and grist	1	} 0	120
Do	do	do	do	Saw	1		
Do	do	do	do	Furniture	1		
Do	do	do	do	Saw	1	5	8
Do	do	do	do	Flour and grist	1	7½	80

Power utilized on the Neosho river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Cottonwood	Neosho	Kansas	Chase	Flour and grist	3	22½	170
Do	do	do	Marion	do	2	10½	99
Small streams	Cottonwood	do	do	do	1	14	28
Do	Neosho	do	Labette	do	1	4½	16
SUMMARY.							
Neosho	Arkansas				15	100	824
Small streams	Neosho				1	4½	16
Spring	do				17	124½	684
Small streams	Spring				24	215	769
Cottonwood	Neosho				11	70½	500
Small streams	Cottonwood				1	14	28
Total					69	534½	2,821

THE VERDIGRIS RIVER.

This stream heads in the southeastern part of Chase county, Kansas, and, following a southerly course into the Indian territory, empties into the Arkansas only a mile or so above the Neosho. It is 190 miles long by general course, and drains an area of 8,010 square miles. Its principal tributaries come from the west, and are as follows: Bird creek, draining 1,228 square miles; Caney river, 2,221 square miles; Elk river, 677 square miles, and Fall river, 848 square miles. The Verdigris basin, in Kansas, at least, is good farming land, but the crops are said to suffer from extremes of rainfall, which is excessive in some years and very deficient in others. The railroad lines cross the river at considerable angles, and do not, therefore, give as good facilities along the immediate course as the Neosho enjoys. The more important towns on the river are Independence, 2,914 inhabitants, and Neodesha, with 924.

The Verdigris is about 120 feet wide at Neodesha in an ordinary stage. This stream and Fall river are said to be similar in character, and are used for power to about the same extent, there being several flouring- and grist-mills on each. They are subject to great fluctuations in volume. In fall, or late summer, they run very low for two months, the lowest stage usually being reached about the first of October. High water occurs from May to July, with a maximum in the middle or latter part of June. The freshet rise is extreme, and is even stated to have been 40 feet in one instance. Both rivers have generally rocky beds, composed of limestone and soapstone, and are inclosed by banks rising 20 to 40 feet above low water. These are occasionally overflowed, and have been so three times since 1869. Fall river is possibly even more unreliable than the main stream, and in about every alternate year runs extremely low. In 1868 it ran dry for two or three weeks. In 20 miles by straight course, or perhaps 40 miles by river, it is said to fall 100 feet.

The earlier dams on the streams in this section are described as having been generally constructed of brush and logs. They answered well enough in a full stage of water, but admitted a serious waste in low water. The present dams are of various types—brush, framed, or stone, usually. They frequently meet with injury, where not properly constructed, most often from the water washing around their ends. The mills are reported to be troubled in many cases by flooding, not having been located sufficiently high above the water.

Estimated volume and horse-power of Verdigris and Fall rivers.

Locality.	Drainage area.	LOW WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
VERDIGRIS RIVER.	*Sq. miles.*						
Middletown	765	10	11	20	23	50	57
Below Fall river	2,063	30	34	60	68	130	148
Independence	2,839	50	57	80	91	180	204
FALL RIVER.							
Charleston	538	5	6	15	17	30	34
Mouth of river	848	10	11	25	28	50	57

NOTE.—Approximate rainfall on the section considered 10 inches in spring, 14 in summer, 7 in autumn, 5½ in winter, and 36½ for the year.

Power utilized on the Verdigris river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Verdigris	Arkansas	Kansas	Montgomery	Flour and grist	6	41	188
Do	do	do	Wilson	do	1	8	20
Fall	Verdigris	do	do	do	4	32	131
Do	do	do	Greenwood	do	3	34½	67
Sundry streams	do	do	Montgomery	do	1	7	18
Do	do	do	Chautauqua	do	4	31	48
Do	do	do	do	Flour, grist, and saw	1	.....	30
Do	do	do	do	Saw	1	6	15
Do	do	do	Elk	Flour and grist	5	59½	122
Total					26	219	639

SUNDRY TRIBUTARIES OF THE ARKANSAS RIVER.

Illinois river joins the Arkansas from the northeast, just above the mouth of the Canadian; its basin comprises 1,470 square miles. The stream heads in the northwestern corner of Arkansas, in Benton and Washington counties, where its upper waters supply power to a number of small mills. It is described as a fine stream, fed from the mountains, clear and constant in flow, and averaging near the mouth at least 100 square feet in cross-section, with a current of 3 miles an hour.

Walnut creek runs southerly through Butler and Cowley counties, in southern Kansas, and joins the Arkansas at Arkansas City. It is about 75 miles long by straight course, and drains 2,005 square miles. There are several flouring- and grist-mills on the stream, the lowest of which, located at Arkansas City, has a fine and expensive stone dam. The mill carries five runs of stone, and obtains sufficient water for about five months in the year to run at full capacity, but uses steam as auxiliary power the remainder of the time; the head on the wheels is 8 feet. At Winfield there are two mills, one supplied through a tunnel about 75 feet long, which has been run across the neck of a bend; 65 horse-power is used, with a head of 8½ feet. There is a fall of about 57 feet between Winfield and the mouth, or say 2.5 feet per mile. In some years the creek furnishes sufficient water throughout to the lower mills, while in other years the supply is entirely below their needs. The Walnut is claimed to be a better stream for power than the prairie creeks emptying into the Arkansas farther west, so it may be judged that those have very little value.

The Little Arkansas river empties from the north at Wichita. It answers for small powers, and is used by a few mills, but the bed is sandy and unfavorable for dams. There was formerly a flouring-mill on the stream at Wichita; it was subsequently burned, but was being rebuilt at the time of my visit. The Little Arkansas drains 1,287 square miles.

Summary of power utilized on the Arkansas river and tributaries.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Arkansas	Mississippi	Kansas	Reno	Flour and grist	2	10	125
Do	do	Colorado	Pueblo	do	1	14	40
Do	do	do	Fremont	do	1	12	60
White and tributaries	Arkansas	Arkansas and Missouri.		(See description)	130	1,031	2,146
Sundry streams	do	Arkansas	Van Buren	Saw	1	10	8
Do	do	do	Conway	do	1	9	25
Do	do	do	Yell	Flour and grist	1	13	20
Do	do	do	Pope	do	2	8	28
Do	do	do	Johnson	do	5	30	52
Do	do	do	do	Woolen	1	.....	8
Illinois and tributaries	do	do	Benton	Saw	1	14	20
Do	do	do	do	Flour and grist	5	82	96
Do	do	do	Washington	do	7	110	113
Neosho and tributaries	do	Kansas		(See description)	60	534½	2,821
Verdigris and tributaries	do	do		do	26	219	639
Walnut and tributaries	do	do	Cowley	Flour and grist	3	22	132
Do	do	do	Butler	do	6	51	160
Little Arkansas	do	do	Harvey	do	3	29	80
Sundry streams	do	do	Barbour	Saw	1	41	42
Do	do	do	Sumner	Flour and grist	2	17	30

Summary of power utilized on the Arkansas river and tributaries—Continued.

Stream.	Tributary to what.	State.	County.	Kind of mill.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Sundry streams	Arkansas	Kansas	Kingman	Flour and grist	1	15	40
Do	do	do	Pratt	do	1	20	20
Do	do	do	Sedgwick	do	4	30	61
Do	do	do	Reno	do	1	18	75
Do	do	do	Pawnee	do	1	13	20
Do	do	Colorado	Las Animas	do	3	42	35
Do	do	do	Huerfano	do	3	85	65
Do	do	do	do	Saw	1	34	20
Do	do	do	El Paso	Plaster	1	26	25
Do	do	do	do	Flour and grist	1	12	20
Do	do	do	Custer	Saw	1	14	20
Do	do	do	Chaffee	do	2	25	50
Total, Arkansas and all tributaries.					288	2,008½	7,000

X.—THE RED RIVER BASIN.

THE RED RIVER.

PHYSICAL FEATURES OF THE COUNTRY, AND DESCRIPTION OF THE MAIN RIVER.

Red river is the most southerly of those great streams which drain the prairie regions east of the Rocky mountains, and then find their way into the Mississippi and the Missouri. In much of its course it is similar to the Arkansas, Kansas, and Platte. It rises in the northwestern part of Texas, a little south of latitude 35°, and about 30 miles east of the boundary between Texas and New Mexico. After running easterly about 200 miles, by general course, it is joined by the North Fork, after which the main river receives numerous accessions, mostly from the north. It forms the southern boundary of the Indian territory, and for a short distance also divides Texas and Arkansas; but soon after entering the latter state its course changes to the south, and it passes into Louisiana. It flows in a southeasterly direction across that state, and empties into the Mississippi 116 miles, by river, above the mouth. It extends through eleven degrees of longitude, and has a length, measured along its general course, of about 810 miles; it is a very crooked stream, however, and its actual length is probably as great as twice the above distance.

The water-shed lines of this river cannot be laid down with accuracy, but inclose an area which I estimate at about 92,700 square miles. Of this area there is contained in Texas, 31,800 square miles; in Indian territory, 25,300 square miles; in Arkansas, 18,600 square miles; in Louisiana, 17,000 square miles. The extent of area drained above various points is as follows:

Drainage areas of the Red river.

Locality.	Square miles.	Locality.	Square miles.
Above North Fork	12,400	Above Little river	68,200
Below North Fork	17,200	Below Little river	71,300
Above Washita river (Indian territory)	32,280	Above Black river	71,500
Below Washita river	40,300	Below Black river	92,500
At Shreveport	61,400	At mouth	92,700

The basin of the river presents great variety in natural features. That portion about its source constitutes a part of the desolate plateau known as the Llano Estacado, with an elevation of 2,500 feet above sea-level. Eastward, as far as the Cross Timbers, between the meridians of 97° and 98°, the country continues barren and unproductive. Beyond that limit, however, it is fertile, well timbered, and covered with vegetation. In Arkansas, around the upper waters of the Ouachita, are low mountains; farther south these subside into hills, and as we approach the main river in Louisiana the country becomes comparatively level, and contains a great many bayous and swamps. All this portion of the Red River basin is heavily timbered, yellow pine, various kinds of oak, and cypress being the principal varieties, besides which there are large amounts of black walnut, maple, beech, sycamore,

hickory, and ash. The soil, and especially the alluvial soil of the river bottoms, is extremely fertile. Cotton is the great staple of production, but corn, wheat, oats, potatoes, tobacco, and hay are also largely raised. A great deal of stock is also shipped from this section to New Orleans. The mineral resources are small, though magnetic iron ore occurs near the sources of the Ouachita.

The climate of the Red River basin is mild, and on the higher and cleared ground is very healthy. Along the river bottoms, with their numerous swamps and luxuriant vegetation, there is the same frequency of chills and fever as in similar regions elsewhere. The average temperature at different points is given as recorded by the Smithsonian Institution:

Temperature of the Red River basin.

Locality.	Years of observation.	Spring.	Summer.	Autumn.	Winter.	Year.
		°	°	°	°	°
Rapides, Rapides parish, Louisiana	10	67.50	80.10	66.53	53.12	66.81
Monroe, Ouachita parish, Louisiana	10	71.53	80.95	59.30	43.87	63.01
Washington, Hempstead county, Arkansas	22	62.26	78.19	61.20	44.01	61.56
Fort Towson, Indian territory	18	62.23	78.02	61.09	43.74	61.50
Fort Arbuckle, Indian territory	12	61.54	80.22	61.07	40.76	61.05
For country thence to source (estimated)			78.50		38.00	62.00

The means of communication in this region must be classed as poor. The Missouri, Kansas and Texas railway crosses the basin, striking the river in the vicinity of Denison, Texas, some 430 miles by general course above the mouth. Again, at Fulton, Arkansas, about 170 miles farther down the river, the Saint Louis, Iron Mountain and Southern line crosses. From Shreveport, still farther down, the Texas and Pacific railway runs westerly, but with the exception of one or two short spurs which touch the outskirts of the basin on the east, there are no other lines of importance. The water routes are very valuable, though they might be much improved. Navigation of Red river extends to Shreveport, 460 miles by water from the mouth, throughout the year, and in high water boats have ascended far above, into the Indian territory. This upper section has very little depth of water at a low stage, contains many obstructions, and above the mouth of Bois d'Arc creek is not considered to have any possible value for navigation. Although steamers of 4 feet draught can reach Shreveport, except in extremely low water, navigation below that point is subject to many dangers and hindrances, owing to its obstruction by snags, leaning timber, and accumulations of logs in the form of rafts. Work has been carried on for many years past, and is still prosecuted, by the general government, to the end of removing existing obstructions, and, so far as possible, preventing the formation of new ones. The most famous of these operations have been in connection with the removal of the great "Red River raft", which was last cut through in 1873 by Lieutenant E. A. Woodruff, of the corps of engineers. Navigation is also carried on up the Black and Ouachita, and some of their tributaries, except in low water.

In the decade previous to 1880 the population of the Red River basin increased nearly 60 per cent., or from 456,000 to 728,000. It is mainly confined to Louisiana and Arkansas, is very much scattered, and is composed chiefly of farmers and planters.

To come more directly to the river itself, as described in Humphreys and Abbot's report it has its source in the eastern rim of the Llano Estacado. Through the Llano its course is in a deep and rugged ravine, shut in by almost vertical sandstone cliffs, rising above it 500 to 800 feet. It here flows over a gypsum formation, which renders its waters nauseating and unwholesome. About 8 miles below the point where it leaves the Llano the river is described as "900 yards wide, flowing over a very sandy bed, with but little water in the channel, and fortified upon each side by rugged hills and deep gullies. * * * The soil throughout this section is a light ferruginous clay, with no timber except a few hackberry and cottonwood trees upon the banks of the streams." Captain Marcy, from whose account the above is quoted, continues: "There is but little water either in the river or in the creeks, and in a dry season I doubt if there would be any found here." The North Fork enters the river on the western border of the Wichita mountains. These consist of detached peaks of a conical shape, evidently of volcanic origin, and present a grand but desolate appearance. Immediately surrounding these mountains the country is fertile and timbered. Between longitudes 97° and 98° the "Cross Timbers" are met with. They are a remarkable strip of timber, 5 to 30 miles in width, extending some 400 miles in a southwesterly direction, from the Arkansas to the Brazos. East of this point the country along Red river is well timbered and very productive. The river itself also changes in character. Previously it has been a wide stream, 2,000 to 3,000 feet across, flowing with quite rapid descent over a sandy bed, and of shallow depth—not more than 6 or 8 feet, even in floods. It now winds through an alluvial bottom, has a muddy bed, a slight fall, is only 600 to 800 feet wide, even as far down as the mouth of Black river, and is subject to oscillations of 40 feet or more. Its character remains substantially the same through the remainder of its course. In what is known as the "raft region", in northwestern Louisiana, it is bordered by numerous extensive lakes and swamps. For the past fifty years there has been a gradual filling up of its mouth, and the consequent throwing of its waters into what is supposed by some to have been its ancient and exclusive channel—the Atchafalaya river.

The elevations and slope of the river are shown in the accompanying table:

Elevations on Red river.

Locality.	Feet above tide.	Intervening distance in miles.*	Average slope in feet per mile.
Source†	2,450.0	504	3.81
Missouri, Kansas and Texas railway crossing, north of Denison, Texas‡	531.0	300	1.02
Saint Louis, Iron Mountain and Southern railway crossing, at Fulton, Arkansas§	226.5		
Same at high water	258.5	265	0.30
Shreveport, high water†	180.0		
Mouth Black river, high water‖	54.0	460	0.28
Mouth Red river, high water¶	49.5		
Mouth Red river, low water**	13.7		

* Of the intervening distances given, the first in order is by careful measurement on Colton's map of Texas; the second is as given in Major W. H. H. Benyaurd's report of a reconnaissance (see 1879 *Report Chief of Engineers*); the third appears from Humphreys and Abbot's report, and the fourth, from Shreveport to the mouth, is from Major Benyaurd's report dated July 1, 1878.

† Elevation as given by Humphreys and Abbot.

‡ Low water, by Missouri, Kansas and Texas railway levels.

§ Low water, by Saint Louis, Iron Mountain and Southern railway levels.

‖ See report Board of Engineers in *Report Chief of Engineers* 1880, page 1285.

¶ See above report Board of Engineers.

** Levels of precision under Coast and Geodetic Survey.

Value for power.—As to the actual availability for water-power of the Red river and its tributaries I can say nothing from personal observation. The streams were too inaccessible and plainly of too little value to warrant spending the time necessary to reach them. By the kindness, however, of Major C. W. Howell, of the corps of engineers, I gained, through his assistants, valuable information of a general character regarding these rivers. Red river itself is said to have no practical value for power, even at a distance of 400 miles west of Denison. This might, indeed, be inferred easily enough from the description previously given. Except, perhaps, toward the extreme source, the river is without abrupt falls, but descends evenly and with no very rapid slope. In the upper section the bed is wide and sandy, and in a low stage contains little or no running water. The tributaries which it receives in that part of its course from the prairies run dry, or nearly so, in summer, and after heavy rains the small streams are subject to sudden and great floods.

The employment of the lower main river for power is evidently out of the question. At what are known as the "Falls of Alexandria" the river descends a few feet, (*a*) but the falls are of no account for water-power, and are visited with a freshet rise of 35 to 40 feet.

The prevailing winds in the Red River basin are southerly, bringing moisture from the Gulf, and resulting in abundant rainfall over that portion which lies at all north of the Gulf. The amount of this precipitation at various points is shown below:

Rainfall of the Red River basin.

Locality.	Years of record.	Spring.	Summer.	Autumn.	Winter.	Year.
		Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Fort Jesup, Sabine parish, Louisiana	10	13.38	10.94	9.79	11.49	45.60
Monroe, Ouachita parish, Louisiana	10					54.00
Washington, Hempstead county, Arkansas	22	15.04	12.42	12.12	14.07	54.25
Fort Towson, Indian territory	14	15.55	14.30	12.23	8.94	51.08
Fort Arbuckle, Indian territory	12	8.86	11.87	8.22	4.02	33.87
Above Fort Arbuckle (estimated)		6.00	6.00	4.00	3.00	19.00

From these records it is seen that the upper basin has a feature common to the rest of the great prairie region west of the Mississippi and Missouri, namely, a much smaller rainfall in winter than in the other seasons. As we advance down the river its ratio rises, and for the lower half of the basin the rainfall both in winter and spring is greater than in summer and autumn. The evaporation being vastly greater in the latter period than in the former, while there is less rain, the result is to bring about great unevenness in the volume of the streams, so that while there is high water from midwinter on to early summer, there is a rapidly succeeding stage of low water, reaching its minimum in late summer or early fall. It is during the high water of winter and spring that navigation

a 3.5 feet in 6,000 feet.

is best in the main river, and many of its tributaries are not, in their present condition, navigable at all, except during those seasons. As to the actual volume of flow in Red river, the only data of importance which I have been able to find are shown below:

Volume of Red river.

Drainage area.	Volume, cubic feet per second.	Cubic feet per second per square mile.	Remarks.
Sq. miles.			
92,700	220,000	2.373	Discharge in the great flood of 1851, when standing at Alexandria 1.1 foot below the highest point attained in 1849. (See *Report of Board of Engineers*, p. 1286 of *Report of Chief of Engineers* for 1880.)
92,700	57,000	0.615	Mean discharge as given by Humphreys and Abbot. Ratio between drainage and rainfall stated as 0.20.
92,500	10,775	0.117	Gauging made by direction of Major Benyaurd, below the mouth of Black river, when Red river was near its low-water mark. (See p. 1295, *Report Chief of Engineers* for 1880.)

TRIBUTARIES OF THE RED RIVER.

The tributaries which Red river receives from the south in Louisiana have no importance for power; they consist of a net-work of sluggish streams and bayous, the latter serving as high-water channels. The Louisiana streams tributary to Red river from the north, with the exception of the Ouachita, have likewise no value. The country through which they flow is heavily timbered with pine, and toward the northern part of the state rises into hills 200 to 350 feet high. The whole district is very sparsely settled, so sparsely, indeed, and so poorly provided with means of communication, that there is even very little cutting of timber. The streams are bordered by rich alluvial bottom-lands, varying from a few hundred feet to three-quarters of a mile in width, and during freshets spread out for miles in width over these and the adjoining country. They are said to have quite a rapid fall, over gravelly beds, but the country drained by them is almost devoid of springs, and in summer the streams, having to depend upon surface drainage, go nearly dry. The only water-powers used are employed by a few scattering grist- and saw-mills, and perhaps occasionally a cotton-gin, but these powers are, for the most part, available only in high water. The names of the more important tributaries of the Red river, and their drainage areas, are given in the following table. The areas are only approximate, for the lower basin is so cut up by bayous that it is impossible to say just where the water-shed lines should run. Of these streams, Black river, which is formed by the Ouachita and Tensas, is navigable throughout. The Ouachita, its main tributary, will be separately described further on.

Tributaries of the Red river (in order from the source).

Name of stream.	Drainage area.
	Square miles.
Salt Fork	1,740
North Fork	4,800
Cache creek	2,000
Big Wichita river	2,040
Big Beaver creek	870
Little Wichita creek	1,300
Mud creek	630
Washita river (Indian territory)	8,100
Blue river	700
Boggy creek	2,760
Kimishi river	2,820
Little river (Indian territory and Arkansas)	3,050
Sulphur Fork	3,770
Cypress creek, at head of Ferry lake	1,900
Bayou Badeau, including Swan lake	1,020
Bayou Dauchitte, including lake Bistineau	1,310
Black Lake bayou, below mouth Saline bayou	1,300
Little river (of Louisiana)	3,100
Black river, including the Ouachita and Tensas	21,000

THE OUACHITA RIVER.

This is the most important stream tributary to Red river, as well as the greatest in extent of area drained. It rises in the Rich mountains, in the northwestern part of Polk county, Arkansas, only a few miles from the western boundary of that state. It runs easterly through Polk and Montgomery counties, after which its general direction becomes southeasterly, and remains so through Arkansas. It enters Louisiana about 50 miles west of the

Mississippi river, as the boundary between Union and Morehouse parishes, and, taking a more southerly course than before, unites with the Tensas on the eastern border of Catahoula parish, to form Black river. By using measurements given in the report of United States engineers, and by careful measurements of the remaining distance on the land-office maps, I find a length of 580 miles for this river, which is, doubtless, considerably under the truth. Its length, measured by general course, is 320 miles. It drains an area of about 19,000 square miles, the general surface features of which have been sufficiently described in connection with the Red river. Its basin comprises the greater part of southern Arkansas, and a large portion of northern Louisiana. Its extent above different points on the river is as follows:

Drainage areas of the Ouachita river.

Locality.	Square miles.	Locality.	Square miles.
Crystal Hill, Montgomery county, Arkansas	350	At Camden	5,000
Harold, Montgomery county	1,000	Above Bayou Moro	6,860
Malvern, Hot Springs county	1,630	Below Bayou Moro	7,400
Above Caddo creek	1,910	Above Saline river	7,540
Below Caddo creek	2,300	Below Saline river	10,370
Above Little Missouri river	2,840	At Monroe	10,050
Below Little Missouri river	5,030	Above junction with Tensas bayou	10,050

Arkadelphia, about 380 miles by water above the mouth of the river, is regarded as the head of steamboat navigation. It is so, however, only during high water, and in medium stages boats do not pass above Camden, some 300 miles from the mouth. In very dry seasons the river runs extremely low, and is practically not navigable. Major Benyaurd has reported, however, that by the improvement of Catahoula shoals, below Columbia, navigation could be assured to that point, say 70 miles from the mouth, throughout the year. The original design for improving the Ouachita contemplated a system of locks and dams, estimated to cost about $1,163,000, and some appropriations were made by the general government for carrying out the plan. It was soon abandoned, and since then work has been mainly confined to the removal of snags. From March 3, 1871, to June 14, 1880, $251,000 had been appropriated to this stream.

From Rockport to Arkadelphia the river is described by Mr. Justin Straszer, civil engineer, as running over a gravelly bed covered with bowlders. (*a*) Overhanging trees, snags, and sunken logs abound. The bottoms are heavily timbered, and in high water are overflowed 2 to 10 feet deep. Heavy rains in the mountains above sometimes cause sudden oscillations of 15 to 25 feet within half a day or a day in this portion of the river. The banks are 15 to 25 feet high, and are firm. "Where the high uplands strike the river the lowest strata of the bluffs expose rocky ledges, which crop out frequently and form at times part of the river bed."

From Arkadelphia to Camden the river averages about 460 feet in width between banks on the shoals. Toward the Louisiana line its average width between banks is about 600 feet. Through these sections the river is winding in its course, and runs through alluvial bottoms, heavily timbered and containing numerous cypress swamps. During high water these bottoms are, as a rule, extensively overflowed.

The elevations and slope of the Ouachita are shown in the accompanying table:

Elevations on the Ouachita river.

Locality.	Miles from mouth.	Feet above tide.	Average fall in feet per mile.
Extreme source *	581	(†) 2,000.00	
Arkadelphia, high water †	380	187.90	9.15
Arkadelphia, low water ‡	380	101.50	
Camden, high water ‡	304	§ 113.50	1.12
Camden, low water ‡	304	76.50	
Mouth Bayou Bartholomew ‖	148	93.00	0.10
Monroe ‖	122	88.00	
Harrisonburg, high water ¶	16	67.00	0.20

* Elevation given by Lieutenant Whipple (quoted by Humphreys and Abbot.)

† Level of water surface where crossed by Saint Louis, Iron Mountain and Southern railway, by profile of that road.

‡ Levels Saint Louis, Iron Mountain and Southern railway.

§ With reference to this elevation J. H. Morley, esq., chief engineer of the Saint Louis, Iron Mountain and Southern railway, wrote me as follows: "It is a curious fact that the Ouachita river at this point, among the hills, should be lower than the Mississippi at Arkansas City, due east therefrom, where high water is 145 feet above tide water, but well verified levels attest the fact."

‖ High water by railroad levels (quoted by Humphreys and Abbot).

¶ Humphreys and Abbot. Delta survey.

a Report Chief of Engineers, 1871.

The river being navigable to Arkadelphia, only that portion above can be considered with reference to water-power. Between Arkadelphia and Rockport the descent of the stream is small, probably not exceeding, on the average, 2 feet per mile. The extreme oscillations in this part of the river, (*a*) and the consequent flooding of the bottoms, render it very unfavorable to use for power. Between Malvern and Arkadelphia, the main line of the Saint Louis, Iron Mountain and Southern railroad follows the stream, giving very direct connections with Texas on the one hand, and with Little Rock and Saint Louis on the other. Nearly the whole of the section of river we are considering lies in Hot Springs county, which has a population of about 7,800; Malvern has about 1,200 (?) inhabitants, and Arkadelphia, which lies in Clarke county, about 1,500.

Above Rockport the river runs from the west, and its course lies among low mountain ranges, which hem it in pretty closely, but nowhere rise above it more than 300 to 600 feet. In the vicinity of Hot Springs the rock is largely slate; what is known as Whetstone mountain is mainly composed of novaculite rock, which is largely quarried and exported for manufacture into whetstones, honestones, and slabs for use in engraving. In this section there is also found a large deposit of magnetic iron ore lying immediately beneath the surface. Garland county has a population of about 9,000, of which 3,600 belongs to Hot Springs. On account of its springs the latter place has become a famous resort for people from all parts of the United States. It lies among low mountains in a narrow valley, through which runs a small stream, called Hot Spring creek, its waters at a summer temperature of 107°. It receives contributions, within the town, from more than fifty mineral springs, the waters of the different ones ranging in temperature from 100° to 148° Fahrenheit. Hot Springs lies about 6 miles north of the Ouachita, and is connected at Malvern with the main line of the Saint Louis, Iron Mountain and Southern railway by a branch 25 miles long. For half that distance the railroad lies less than 2 miles from the river, and occasionally approaches it closely.

Throughout the upper portion of its course the fall of this river is quite rapid; there are no abrupt descents, but successive riffles, with here and there a quiet stretch intervening. The stream is less than 200 feet in width between banks, and has a rocky bed much of the way, very favorable to dams. I was informed by the surveyor of Garland county that there are numerous good sites to be found, naturally well suited to the location of mills, and out of reach of high water. It is stated that at some points 18 feet fall is available within half a mile. The stream is utilized at only one or two points in its whole length. The more important of these is Thornton's mill, 8 miles from Hot Springs; a fall of 9 feet is employed, power being supplied to a small two-run grist-mill, a cotton-gin, and a saw-mill. The utter absence of all railroad facilities above Hot Springs would preclude, at present, any important use of the stream for power, even if there were no other obstacles. Probably the true reasons for the small employment of water-power in this section are the sparse population, almost entirely devoted to farming, their inaptitude for manufacturing pursuits, their distance from important markets, and their lack of capital. As described by Humphreys and Abbot, the Ouachita has its source in sterile, mountainous prairies; toward the headwaters of the Little Missouri, however, these disappear, the soil becomes more fertile, being adapted to potatoes and small grains, and timber abounds, including considerable tracts of pine and black oak. The extent to which cotton is raised in the Ouachita basin may be inferred from the report (*b*) of Major Benyaurd, corps of engineers, who states that during the fiscal year ending June 24, 1879, the amount of cotton shipped down the Ouachita from the country along the main stream and its tributaries, Saline river, Bayou Bartholomew, Bayou d'Arbonne, and Little river, reached 179,700 bales, with a value of $7,188,000. The basin of this river also yields largely in corn, wheat, and tobacco.

In the vicinity of Hot Springs the width of the Ouachita between banks ranges from 150 to 200 feet, but in very low water the stream scarcely covers its bed, and can easily be walked across in places. Its water-shed being rocky, with abrupt slopes, the river is subject to great oscillations; it rises rapidly after a heavy rain, sometimes coming up 10 or 15 feet in a single night. Humphreys and Abbot quote Darby as saying of this river:

> Few rivers differ more in the quantity of water at different seasons than the Ouachita. Flowing from a hilly or mountainous tract, more constancy might be expected in the column of water; but though the places drained by the Little Missouri and Fourche Caddo are not deficient in springs, yet the extensive region toward the sources of the Ouachita has little water except what is supplied by rains in winter and spring. When the parching heat of summer has dried the country above the mouth of the Little Missouri, the Ouachita becomes very low as far south as the head of Black river.

If we take the record kept at Washington, Hempstead county, as applicable to the upper basin of the Ouachita, its temperature is about as follows: Spring, 62°; summer, 78°; autumn, 61°; winter, 45°; year, 61.5°.

There are no long-continued records of rainfall in the upper Ouachita basin, but from the Smithsonian rain charts I estimate the precipitation as follows: Spring, 15 inches; summer, 12 inches; autumn, 11 inches; winter, 12 inches; total for year, 50 inches. While the temperature is considerably above freezing in winter, it is much lower than that which produces the great evaporation of summer; again, the rainfall during winter and spring is, in the aggregate, 4 inches more than in the remainder of the year. We thus, naturally, find high water prevailing during the former period, followed by decreasing stages during the summer and autumn. Mr. Straszer, in his report previously referred to, states that high water sets in about December 1, and a fair stage continues on through the spring freshets. Low water begins in June, the lowest stage being usually in August and September.

a The range between extreme high and low water at Arkadelphia is 26½ feet.

b See *Report Chief of Engineers*, 1879.

Two gaugings have been made on the Ouachita, with the purpose of finding its low-water volume. I am informed by Major Benyaurd that, in a report to Colonel W. F. Raynolds, in 1872, Clement Smith, assistant engineer, stated that he had gauged the Ouachita at Monroe, when the river was some 10 or 12 inches above its lowest stage, and found the discharge about 800 cubic feet per second. He deduced that the low-water discharge at Monroe was about 600 cubic feet per second, and that at Camden the discharge could not be over 400 cubic feet per second.

In 1874, Mr. Durham, assistant engineer to Major Benyaurd, gauged the river at Camden, and gave the resulting low-water discharge at 353 cubic feet per second. The results of these various gaugings and estimates may be thus presented:

Gaugings and estimated volume of the Ouachita river.

Locality.	Drainage area.	RAINFALL ON TRIBUTARY AREA.					Volume, cubic feet per second.	Cubic feet per second per square mile.	Remarks.
		Spring.	Summer.	Autumn.	Winter.	Year.			
	Sq. miles.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*			
Camden	5,600	15	12	11	12	50	353	0.063	Low water, as estimated by Mr. Durham, 1874.
Do	5,600	15	12	11	12	50	400	0.071	Low water, as estimated by Clement Smith, 1872.
Monroe	16,050	17	12	11	14	54	600	0.037	Low water, as estimated by Clement Smith.
Do	16,050	17	12	11	14	54	800	0.050	Gauging by Clement Smith; river 10 or 12 inches above low water.

The following table gives my estimate of the volume and corresponding horse-power at several points on the upper Ouachita. The estimate is for the constant flow of the river, independent of storage afforded by dams:

Estimated volume and horse-power, Upper Ouachita river.

Locality.	Drainage area.	LOW-WATER, ORDINARILY DRY YEAR.		LOW WATER, AVERAGE YEAR.		AVAILABLE 10 MONTHS IN AVERAGE YEAR.	
		Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.	Volume, cubic feet per second.	Theoretical horse-power, 10 feet head.
	Sq. miles.						
Crystal Hill, Montgomery county	350	10	11	20	23	45	51
Harold, Montgomery county	1,000	50	57	80	91	170	193
Malvern, Hot Springs county	1,630	90	102	150	170	300	341
Below Caddo creek	2,390	150	170	220	250	440	500

The more important tributaries of the Ouachita, in order from the source, with their drainage areas, are as follows:

	Square miles.
Caddo creek	480
Little Missouri river	2,190
Smackover creek	540
Bayou Moro	570
Saline river	3,430
Bayou Bartholomew	1,950
Bayou Loutre	440
Bayou D'Arbonne	1,910
Bayou Boeuf	2,190

I have very little detailed information regarding any of these streams. In their lower courses they would be found altogether too sluggish to be of value, and in their upper waters they have too little volume to carry any but small powers. There is an occasional small grist- or saw-mill to be found on their upper portions, or on some tributary; otherwise they are unused for power. The larger of the streams in the above list are navigable during high water for some little distance above their mouths, but without exception they are either very poorly or not at all provided with railroad facilities. The upper waters of the Saline and the lower course of the Little Missouri are crossed almost at right angles by the Saint Louis, Iron Mountain and Southern railway; Bayou Bartholomew and Bayou Boeuf are also crossed by short lines running to the Mississippi, but the other streams are not even touched by any railroad.

Little Missouri river rises in the southeastern part of Polk county, Arkansas. It flows southeasterly and joins the Ouachita 25 miles above Camden. In high stages it is navigable about 68 miles (by river) above its mouth, to Antoine creek. In this distance it averages about 300 feet in width between banks. Its course lies through alluvial

bottom-land, 4 to 6 miles in width, covered with heavy timber, canebrakes, and cypress swamps, and intersected with bayous. Some of the bottoms are above the reach of freshets, and are cultivated. As a rule, however, they are overflowed 3 to 10 feet deep during high water. A large part of the territory drained by this river is "black land", 100 to 200 feet thick, underlaid by the Cretaceous formation. It yields 1,800 pounds of cotton in seed, and 60 to 75 bushels of corn, per acre.

Saline river is formed by small forks rising in Saline and Garland counties, Arkansas, 18 to 20 miles north of Hot Springs, and 40 to 45 miles west of Little Rock.

Its course is southeasterly, and afterward southerly, joining the Ouachita on the eastern border of Union county, 10 miles north of the Louisiana line. Its drainage area is 3,430 square miles. This stream was examined and reported upon, in the winter of 1878–'79, by Mr. Zeph Harrison, civil engineer. (*a*) He states the length of the river to be about 485 miles. The Saint Louis, Iron Mountain and Southern railway crosses the stream at Benton, in its upper waters. For 225 miles below that crossing the river is tortuous and full of shoals, its bed and banks are gravelly, and its course is obstructed by many jams of timber and drift. The bottoms bordering the stream are very productive and yield good crops of cotton and grain. The valley of the stream and the ridges on either side are covered with a heavy growth of valuable timber—white oak, yellow pine, and a great many other varieties. The stream is not used for water-power, and does not appear to be favorable to such employment. In the lower river the fall is estimated at about 5 inches per mile. The Saline is said to be navigable 70 or 80 miles from its mouth in high water.

The character of the upper portion of Bayou Bartholomew may be sufficiently judged from the following description by Mr. M. L. Lum, civil engineer:

The principal source of the bayou is Bird's spring, situated among the pine hills in the westerly part of Jefferson county, and distant 16 miles northwest from Pine Bluff. Before reaching the Louisiana line the bayou flows through Jefferson, Lincoln, Drew, and Ashley counties, touching Desha and Chicot counties on the west, the general course being parallel with the Arkansas river, at distances from it varying from 15 to 30 miles. The current is very sluggish, there being very few places where the velocity is 2 miles per hour, and the course of the bayou exceedingly tortuous. In the vicinity of Pine Bluff the Arkansas river is distant only 4 miles from the bayou, and at its highest stage has been known to flood the intervening country, and here it is proposed by parties interested in the bayou to have a canal cut, thus relieving the Arkansas river, in a measure, at its highest stage, and increase the current in the bayou, thereby removing some of the obstructions and benefiting the health of the people along its banks.

For a distance of 20 miles below Pine Bluff, on the right bank of the bayou and adjacent to it, are found bluffs 50 feet in height, covered with pine and scrub-oak, with soil of a sandy nature, while on the opposite side it partakes of the character of the Arkansas River valley, the soil being in most places what is termed "buckshot", and the land being overflowed in high water for a distance of one-half mile back from the bayou, the overflow having an extensive growth of gum, cypress, water-oak, and hickory.

Power utilized in the Red River basin.

Stream.	Tributary to what.	State.	County.	Kind of mill or manufacture.	Number of mills.	Total fall used.	Total horse-power of wheels.
						Feet.	
Ouachita	Red	Arkansas	Hot Springs	Cotton-gin	1	9	20
Do	do	do	Garland	Flour, grist, and saw	1	9	37
Do	do	do	do	Saw	1	20	25
Sundry streams	Ouachita and tributaries	do	Union	Flour and grist	3	25	24
Do	do	do	Ouachita	Saw	1	9	18
Do	do	do	Hempstead	do	1	6	24
Do	do	do	do	Flour and grist	2	15	23
Do	do	do	Dallas	do	3	20	37
Do	do	do	do	Saw	1	6	20
Do	do	do	Grant	Cotton-gin	1	8	30
Do	do	do	Saline	Saw	1	8	22
Do	do	do	do	Flour and grist	1	9	15
Do	do	do	Pike	do	3	35	102
Do	do	do	do	Flour, grist, and saw	1	15	25
Do	do	do	do	Cotton	1	10	48
Do	do	do	Hot Springs	Cotton-gin	2	15	33
Do	do	do	do	Saw	1	18	30
Do	do	do	do	Flour and grist	5	20	81
Do	do	do	Garland	do	1	20	15
Do	do	do	do	Saw	1	24	15
Do	do	do	do	Hones and whetstones	1	17	20
Do	do	do	Montgomery	Flour and grist	5	90	98
Do	do	do	Polk	Flour, grist, and saw	1	5	16
Total					39	422	778

a Chief of Engineers' Report, 1879.

Summary of the total utilized power on the western tributaries of the Mississippi river, below Dubuque.

Section.	Number of mills.	Total fall used.	Total horse-power of wheels.
		Feet.	
Eastern Iowa slope	340	2,812	15,410
Eastern Missouri slope	73	852	1,466
Missouri River basin	581	6,564	21,012
Arkansas River basin	288	2,608½	7,096
Red River basin	39	422	778
Total	1,321	13,278½	45,762

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